WoodEMA

Green Deal Initiatives, Sustainable Management, Market Demands, and New Production Perspectives in the Forestry-Based Sector

Sofia, Bulgaria, May 15th-17th 2024

WoodEMA, i.a. – International Association for Economics and Management in Wood Processing and Furniture Manufacturing

Sofia University St. Kliment Ohridski

Researchers' excellence network (RENET), Vilnius University, Šiaulių Akademija

International Business School

Higher School of Insurance and Finance (VUZF), Bulgaria

Refan, Bulgaria

ET Rositza Georgieva - Danivers

GREEN DEAL INITIATIVES, SUSTAINABLE MANAGEMENT, MARKET DEMANDS, AND NEW PRODUCTION PERSPECTIVES IN THE FORESTRY-BASED SECTOR

Proceedings of Scientific Papers

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PREFACE

Dear colleagues, experts, and friends of the WoodEMA international association,

We are pleased to present the book of proceedings from the 17th WoodEMA international scientific conference ‘Green deal initiatives, sustainable management, market demands, and new production perspectives in the forestry-based sector, held in Sofia, Bulgaria, from May 15th to May 17, 2024.

The conference aimed to transfer knowledge and good practices from the field of economics and management of the forest-based sector. Topics under consideration and discussion are improving sustainability through new production perspectives; new market trends, management practices and innovations; sustainable macroeconomic perspectives, green deal and climate change initiatives; ESG reporting and auditing control; and sustainable design and construction within the forest-based sector.

This year WoodEMA i.a. partnered with ET Rositza Georgieva – Danivers; Sofia University St. Kliment Ohridski; Researchers' excellence network (RENET), Vilnius University, Šiaulių Akademija; International Business School, Bulgaria; Higher School of Insurance and Finance (VUZF); and Refan, Bulgaria to organize the conference event. We would like to thank Vellea Home/Furniture Videnov, Bulgaria for their cooperation and the opportunity to see good practices from the Bulgarian furniture industry.

After the review process, the conference book of proceedings includes 59 scientific articles authored by 109 scientists and experts representing 10 European countries. This book includes five main axes of scientific papers which introduce readers to interdisciplinary and various debates about conceptual ideas and approaches towards sustainable, innovative and productive forestry-based sector.

WoodEMA 2024 international conference was conceived as a space for debate and networking among academics, experts and professionals in the forestry and wood-based industries. We are grateful to all authors and conference participants who presented their analysis and points of view regarding important topics of the current market demands and competitiveness, sustainability, as well as new perspectives, innovative ideas and new approaches towards the successful and sustainable forest and wood-based sector.

We believe that the outcomes of the 17th International Scientific Conference WoodEMA 2024 and the book of proceedings will be valuable in future work to all scientists, teachers, experts, professional, and enthusiasts in the forest and wood-based sector.

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INVITED PAPERS

SELECTED ECONOMIC AND HEALTH RISKS IN THE PROCESS OF PRODUCTION AND STORAGE OF BIOMASS FOR ENERGY PURPOSES

Miloš Gejdoš, Marek Potkány

Abstract: The paper deals with the analysis of risks that arise in the process of production and storage of forest biomass, which is used for the production of heat and electricity. The risks that can potentially threaten human health and property due to the long-term storage of forest chips in large-capacity piles in urban-type heating plants were analyzed, as well as the risks that arise in the harvesting process, concentration, and chipping. The risk analysis was based on the collected data of the last 5 years. Data collection was carried out continuously. The identification of health risks was carried out by an accredited laboratory of the regional office of public health in the Slovak Republic. As a result of the identification of risks, calculation models of potential economic damages caused as a result of occupational diseases and property damage in various stages of the biomass production or storage process were established. The obtained results provide information for the creation of optimization models within the production and storage process, both for biomass producers and operators of urban heating plants.
Keywords: biomass, health risks, economic risks, biomass storage, wood chips, phytopathogens

1. INTRODUCTION

The European Union has prioritized renewable energy sources in the past decade, with a target for these sources to cover 32% of final energy consumption by 2030. Among these sources, biomass, including the biodegradable part of waste, stands out as a crucial component, constituting 63.3% of total energy production from renewables in the EU (EU Audit Team, 2018). Agriculture and forestry play a vital role in meeting these renewable energy goals.

As demands for the production volume and utilization of forest biomass continue to rise, so do the requirements for ensuring technological, material, and personnel security. Beyond the production potential of forest stands and the escalating need for their protection and sustainable management, factors that will significantly influence the attainment of these goals include the availability of a high-quality workforce and the requisite technologies. It is noteworthy that there is a critical shortage of workers in the agriculture and forestry sector. Moreover, these jobs are often perceived as risky and inadequately remunerated. Addressing these labor challenges becomes imperative not only for meeting renewable energy targets but also for sustaining a balanced and secure approach to biomass production.

The entire logistics chain, which includes the production, storage, and consumption of forest biomass as an energy source, brings a whole spectrum of different risks and dangers that can cause damage to health, endanger the lives of workers, as well as the risk of deterioration or damage to property and equipment. Work in forestry is extremely demanding from the point of view of minimizing the risk of occupational accidents and occupational diseases, especially due to specific production and technical conditions, different levels of mechanization of work and technologies and their state of wear, high degree of exertion in various weather conditions and neuropsychological burden on workers. Since 2008, the number of employees of forestry enterprises in the Slovak Republic has decreased by more than 15,000 (mainly in blue-collar professions). Most of these workers have moved to the private sector, where the requirements for compliance with the rules of safety and health protection at work are relativized and, unless there is serious damage to health, the workers mostly avoid their records.

The aim of the work is the analysis and economic quantification of the risks that arise especially during the long-term storage of forest chips, which in the long-term context can become a serious problem for human health, especially from the point of view of the production of phytopathogens and wood dust. This problem arises mainly because of the frequent placement of stored piles of forest chips directly in the urban areas of villages and towns, often close to human dwellings. Not only the workers who work and handle the wood chips are at risk, but also the people living near the storage sites.

2. METHODOLOGY

The long-term monitoring initiative focuses on three urban heating plants situated in the Banská Bystrica Self-Governing Region. These heating plants, all belonging to a single company, utilize wood chips stored in large-capacity piles on-site to generate heat. Notably, the plants are located in inner-city areas with inhabited buildings nearby. Sample collection for the monitoring program occurred between 2019 and 2023, involving the extraction of five samples from each heating plant—three from the surface of the piles and two from a depth of 0.5 meters. All collected samples underwent microbial analysis at the accredited laboratory of the Regional Office of Public Health in Poprad to detect the presence of phytopathogens.

In parallel, a dust measurement was conducted in one of the heating plants during the winter period in 2023. The CEM DT-9880 device was employed for dustiness measurement. The assessment of dustiness in the environment aligns with Government Regulation no. 356/2006 Coll. and is evaluated as harmful to human health based on the technical guideline value for the respirable component of wood dust, set at 3 $mg.m^{-3}$. However, there is currently no guideline value in legislation for exposure to phytopathogens.

According to the World Health Organization (WHO) standard from 2021, healthy air is defined as having an average daily concentration of PM2.5 dust particles not exceeding 15 $\mu g.m^{-3}$ (Pai et al., 2022).

From an economic perspective, the impact of the potential occurrence of occupational diseases during the production and storage of biomass was assessed. The following were identified as potential diseases that may arise in the logistical process of production and use of biomass: Lung and respiratory tract cancer, Allergic diseases of the respiratory tract, Hearing loss, Occupational deafness, Vibration disease, Diseases of bones, joints, tendons, and nerves of the limbs due to long-term, excessive, and unilateral loads. For the economic classification of these diseases, valid legislation was utilized (Act No. 437/2004 Coll., the database of the National Center for Health Information – NCHI, regulations of the Social Insurance Company). Laws 461/2003 and 311/2001 were used to implement legislative regulations that define procedures and financial compensation for recognized occupational diseases. Information from the Statistical Office of the Slovak Republic served as the input data for quantifying economic risks. With the use of the markup, a calculation method was proposed a framework for allocating overhead costs, which also considered the risk of financial compensation for occupational diseases. The relationship for difference determination of overhead cost surcharge – ∆OCS (1) and general calculation formula was used in this study:

$$\Delta OCS = \frac{Difference\ in\ overhead\ costs\ by\ calculation\ risks}{Allocation\ base} . 100\ (\%) \quad (1)$$

3. RESULTS

3.1. Identification of phytopathogens in urban-type heating plants

Table 1 provides an overview of the abundance of phytopathogen species observed during sampling within the time interval of 2019-2023. On average, 6 to 7 types of phytopathogens, molds, and yeasts were identified at individual storages in heating plants throughout all monitored years. The majority of the identified species pose a potential risk to human health if workers are exposed to them over an extended period. Among the most frequently identified species were phytopathogens belonging to the genera *Aspergillus sp.*, *Penicillium sp.*, *Mucor sp.*, and yeasts.

Table 1. Number of species of identified phytopathogens in 4 urban-type heating plants in 2019-2023

Year	Storage Nr.1 (number of ident. species)	Storage Nr.2 (number of identified species)	Storage Nr.3 (number of ident. species)
2019	7	6	8
2020	10	7	6
2021	5	6	5
2022	7	7	6
2023	6	5	5
The most common identified species	*Penicillium sp.*	*Aspergillus flavus*	*Aspergillus niger*

Species of the genus *Aspergillus sp.* are known to cause serious respiratory diseases, including respiratory and skin allergic diseases. One notable lung disease associated with *Aspergillus* is Aspergillosis, which carries a 20% mortality rate (González-García et al., 2022). Additionally, these species can induce carcinogenic diseases, particularly in individuals with compromised immune systems. Fungi belonging to the genus *Mucor sp*. can lead to various fungal diseases, such as mucormycosis, affecting the skin, respiratory system, and organs of vision (Steinbrink and Miceli, 2021). Species of the genus *Penicillium sp.* are capable of producing mycotoxins that have the potential to cause serious allergic and carcinogenic diseases (Otero et al., 2020).

The presence of hazardous phytopathogens has been consistently identified in large piles of wood chips over extended periods, even when there is a continuous supply and withdrawal of biomass in operations. Consequently, these piles pose a persistent health risk for both workers and residents living in close proximity to such facilities. Although research has yet to determine the specific duration of exposure required for the development of dangerous diseases, it can be confirmed that an extended exposure duration increases the risk of disease development. The risks associated with these conditions are primarily linked to the biological processes occurring within the stored material. Studies indicate that the concentration of spores in the air drops below the threshold of 1000 CFU.m^{-3} (Colony Forming Unit.m^{-3}) up to a distance of 300 meters from the wood chip piles during handling. Therefore, this area can be considered a threatened zone with a potential health risk (Barontini et al., 2014).

The current legislation does not clearly specify the harmfulness of the factors associated with working with biomass, nor does it outline the obligations for ensuring health and safety at work in connection with exposure to these factors and their magnitude. Furthermore, there is a lack of guidelines for establishing and operating large-capacity piles, as well as for assessing the associated risks. The existing directives primarily focus on fire safety aspects, providing technical guidance from a fire risk perspective. A significant challenge is that the majority of heating plant operators and biomass producers lack detailed information about these serious health risks. Similarly, residents in urban areas with dwellings near these operations are often unaware of these risks. Several research studies have confirmed the reality of these risks, with documented cases of diseases causally linked to exposure. Consequently, it becomes evident that addressing safety and health protection issues when working with biomass will likely require legislative intervention in the near future.

3.2. Identification of exposure to dust in urban-type heating plants

In recent years, air quality has deteriorated in inner-city areas due to increased traffic intensity and the growing consumption of biomass for energy, particularly during the heating season. The operation of a heating plant burning biomass creates several sources of increased dust generation. A large-capacity chip storage is itself a source of phytopathogen spores and dust, originating from polluted wood or its processing. Handling the wood chips at the chip storage further increases the concentration of dust particles in the air. The burning of biomass in the heating plant releases solid dust particles into the air.

These factors significantly increase the exposure of workers and residents living in the vicinity of the facility to respirable dust particles, especially PM2.5 and PM10 particles. When analyzing dustiness, it is important to distinguish between occupational exposure and environmental exposure. While a 2-hour measurement during a work shift is sufficient for assessing occupational exposure, a minimum 24-hour measurement is required for evaluating environmental exposure.

On November 22, 2023, and January 10, 2024, the initial measurements of dust particles were carried out with a CEM DT-9880 mobile environmental dust analyzer for the operation of an urban-type heating plant. The atmospheric conditions under which the measurements were conducted corresponded to the autumn and winter seasons. On both measurement days, they were very similar (average air temperature during the measurement was 4°C, relative air humidity 73.4%, wind flow westerly, 20 km/h). The measurement methodology corresponded to the provisions of the standards STN EN 689+AC Occupational exposure. Measurement of inhalation exposure to chemical agents. Strategy for testing compliance with occupational exposure limit values; STN EN 482 Occupational exposure. Procedures for determining the concentration of chemical factors. Figures 1 and 2 show the results of the first and second dust measurements in the working environment of the heating plant conducted on November 22, 2023, and January 10, 2024, respectively, during the autumn and winter periods. The measurement results during this period indicated relatively low concentrations of risk particles ranging from PM2.5 to PM10. Much higher concentrations were observed for dust particles of smaller sizes, ranging from PM0.3 to PM1. However, the concentration of wood dust in the working environment did not exceed the limit values set by applicable legislation (3 mg/1m^3) during the measurement interval. The influence of windy weather during the first measuring day proved to be significant, particularly when strong winds occurred between 11:00 AM and 12:00 PM.

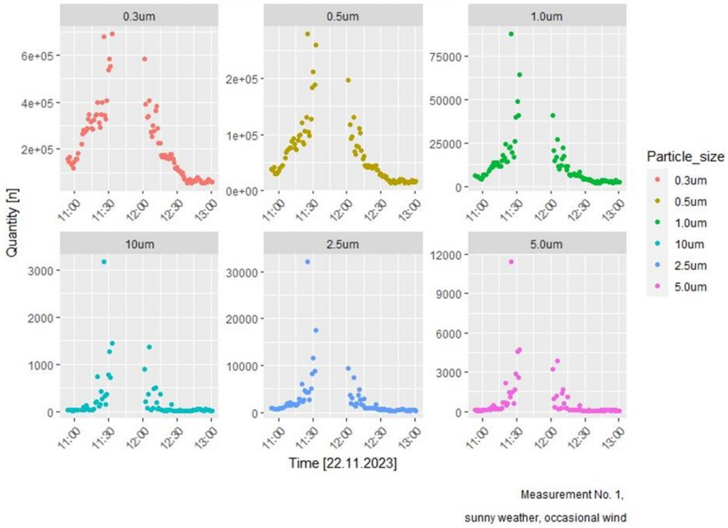

Figure 1. The concentration of dust particles during the measurement period on November 22, 2023

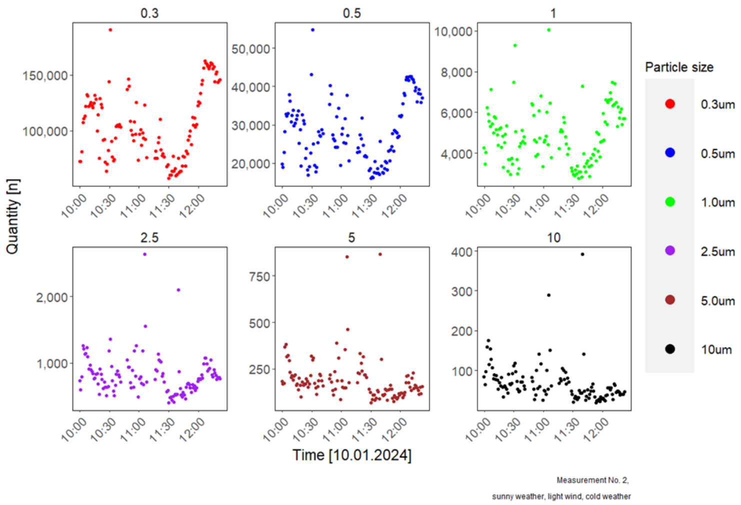

Figure 2. The concentration of dust particles in the two-hour measurement period on 10.1.2024

3.3. The economic risks arising from health damage in biomass production and storage

The logistics chain of biomass production and storage can be divided into three phases. The first involves the establishment, cultivation, and protection of fast-growing tree plantations and intensive crops. The second phase includes biomass and wood chip production, and the third phase involves storage and combustion of biomass for energy purposes (Gejdoš, Lieskovský, 2024). Several health and safety risks occur simultaneously in two or all three phases of the logistics chain. Besides the highest risk of loss of human life, the economic burden on the national economy or a specific enterprise includes the risk of occupational diseases or serious health damage. These may result in a court order to compensate for damages or provide severance pay. An occupational disease is recognized by the relevant healthcare facility and included in the list of occupational diseases if it occurs during work (the Social Insurance Act 461/2003 as amended). If an employee is recognized with such an occupational disease, the employer is obliged to:

- To transfer the employee to another job position taking into account his health condition,
- If the employee is forced to leave work due to an occupational disease, severance pay must be paid to him (a minimum 10 times the average monthly salary of the employee),
- An employee recognized with an occupational disease is entitled to compensation for damages. This is paid out by the social insurance, but the court may also determine its compensation from the employer.

Considering the identified existing risks in the process of biomass production, storage, and consumption, according to the national classification of diseases and health damage, we have selected the following diseases that may arise based on the impact of risks in this process:

1. Lung and respiratory tract cancer; 2. Allergic respiratory diseases; 3. Disease from long-term excessive unilateral limb loading; 4. Unilateral hearing impairment; 5. Bilateral hearing impairment; 6. Unilateral deafness; 7. Bilateral deafness; Vibration-induced disease; 9. Occupational dermatosis (according table 2).

Each of these diseases has a point value assigned within the national legislation in a certain range (Law No. 437/2004 Coll. as amended by subsequent regulations). For economic analysis, the maximum value of the disease was always used. Each assigned point has a quantified value in Euros, which is derived from the average wage in the national economy. For the year 2023, the value of one point was €26.08. The point values of individual diseases and their quantified values in Euros are listed in Table 2.

Table 3 shows the number of recognized classified diseases in the agriculture, forestry, and wood processing sectors for the period from 2016 to 2022.

From the table, it is evident that not all diseases identified as possible due to the effects of risk factors in the production and utilization of biomass were identified in the social system. Among the most common diseases were vibration-induced diseases and long-term excessive unilateral limb loading. Allergic diseases and dermatoses occurred nine times in the given period (Table 3). Long-term exposure to phytopathogens and dusty environments has not yet been clearly associated with the occurrence of lung and respiratory tract cancer in the healthcare system, although numerous studies worldwide demonstrate this connection. This fact is influenced by the difficulty in demonstrating and monitoring the long-term impact of this work environment on human health.

Table 2. The economic values of selected occupational diseases and injuries according to national legislation.

Disease	Point value	Quantified value (€)
1	1000	26,080
2	800	20,864
3	150	3,912
4	120	3,129.6
5	500	13,040
6	400	10,432
7	1000	26,080
8	1000	26,080
9	1700	44,336

Table 3. Registered diseases in Slovakia in the agriculture, forestry, and wood processing sector for the years 2016-2022 and their economic value in Euros.

Year/Dis.	2022	2021	2020	2019	2018	2017	2016	Together	Costs in €
2				2	2	1	2	7	146,048
3	5	12	14	15	11	15	7	79	309,048
5	1	1	5	1	2	2	2	14	182,560
8	1	5	4	16	15	15	9	65	1,695,200
9			1	1				2	88,672
Together	7	18	24	35	30	33	20	167	**2,421,528**

From the perspective of the economic burden on the social system, the greatest risk is the occurrence of vibration disease, which accounts for up to 70% of the total costs of recognized occupational diseases in the sector. Less health damage in the set point evaluation and consequently, a lower economic burden for the social system, is represented by recognized diseases from long-term excessive unilateral loading of the limbs, which are the most frequent, but the total economic burden represents only 12.7%. It should also be noted that the calculated economic burdens only cover compensation for clearly identified occupational diseases of workers in the industry. Additional costs arise from the burden on the health system and social care resulting from these diseases (which cannot be precisely calculated). The hidden economic burden stems from the illnesses of workers in the industry who did not apply for a declaration of occupational illness or failed to prove a causal link, although it is highly likely that their illnesses could have arisen in connection with the fulfillment of their work duties (e.g., in the case of cancer).

Every company should also consider the risks associated with paying severance pay or compensation for occupational diseases as part of its cost calculation. If these risks are insured, they are reported in the overhead cost item as "Insurance costs." However, if they are not insured, the question arises: How and to what extent can these risks be quantified and allocated to the prices of their products? This is also the basic research question (RQ) of our study.

Therefore, we suggest specifying these risks as a special cost item called "calculation risks." We also propose their final allocation in cost items: severance pay (Table 4) and payment of damages (Table 5). For quantification, data from the Statistical Office of the Slovak Republic and NCHI were used. We also propose the final allocation of costs using the mark-up method of calculation in the full cost calculation system. For the basic conversion relationships and the structure of the calculation, we relied on recommended procedures published in the studies Král et al. (2018), Popesko and Papadaki (2015) and Potkány, Krajčírová (2015).

Table 4. Quantification of calculation risks in case of severance pay

The number of recognized occupational diseases in the year 2022	525 cases
The number of employees in the national economy in the year 2022	2,580,000 empl.
The number of employees in the industrial sector in the year 2022	516,616 empl.
The average wage in the industrial sector in the year 2022	1,430 €/empl.
Arguments for quantification of the cost item “calculation risks”: - the share of occupational diseases in the national economy 0.02% - the share of occupational diseases in the industry sector: 0.10% Proposal for the quantification of the cost item "calculation risks (CR_{SP})": CR_{SP} = (the number of employees in operation /1000) x 1,430 € x 10 months’ x 1.362** * for the number of 100 employees in operation, the calculation risk of severance pay/year is 1,950 € **employer's contributions to the social and health insurance company	

Table 5. Quantification of calculation risks in case of payment of damages

The average number of recognized occupational diseases (2016-2022*)	3,962 cases
The total number of recognized occupational diseases (2016-2022**)	167 cases
The economic value of recorded diseases (2016-2022*)	57,450 000 €
The economic value of recognized diseases (2016-2022**)	2,421,528 €
Arguments for quantification of the cost item “calculation risks”: - average ratio of economic value of occupational disease/case in national economy and in the sector of agriculture, forestry and wood processing industry 14,500 €/case Proposal for the quantification of the cost item "calculation risks (CR_{PD})": CR_{PD} = (the number of employees in operation /1000) x 14,500 €*** * in national economy ** in the sector of agriculture, forestry and wood processing *** for the number of 100 employees in operation, the calculation risk of payment of damages/year is 1,450 €	

It is evident that the frequency of occurrence and the risk of financial compensation for an occupational disease will vary individually for each company and may not align with our proposed calculated values converted to the number of employees (i.e., for 100 employees CR_{SP} €1,950/year and for the CR_{PD} alternative €1,450/year). From our perspective, it is necessary to calculate the risk of occupational disease at the maximum level, serving as a certain reserve for the potential occurrence of similar expenditures in the future, i.e., CR_{SP} €19,500/year and for the CR_{PD} alternative €14,500/year (total €34,000/year). However, this fact needs to be incorporated into the overhead cost calculation proposal. Therefore, we will utilize a model cost structure that realistically reflects the condition of the selected company in the industry (direct cost €800,000 = allocation base, overhead cost €400,000, profit €50,000, profit margin based on Return on Cost = ROC 4.17%, overhead cost surcharge % OCS = 50%). To quantify the impact of economic risks on the calculation of final products, it is possible to apply the general calculation formula. To determine the overhead cost surcharge, it was necessary to apply formula 1:

$$\Delta OCS = \left(\frac{34{,}000€}{800{,}000€}\right).100 = 4.25\ \% \ (1)$$

The given difference will subsequently have an impact on the difference in profit margin ∆ PM (2), and both changes will mutually affect the possible change in selling price ∆ SP (3):

$$\Delta PM = \Delta OCS.ROC/100 \ (2)$$

$$\Delta SP = \frac{\frac{\Delta OCS+\Delta PM}{100}.allocation\ base}{selling\ price}.100 \ (3)$$

The schematic representation of the calculation formula allocating the potential occurrence of occupational disease risks then has the following structure utilizing the mark-up method of calculation in the full cost calculation system:

1. Direct cost (direct materials, direct wages, others direct cost)
2. <u>+ Overhead cost (% </u>surcharge<u> with using of ∆ *OCS)*</u>
3. *= Total own cost*
4. <u>*+ Profit margin (with using of % ROS and ∆ PM)*</u>
5. *= Selling price without VAT (with determination of ∆ SP)*

By applying a cost structure model, allocating calculation risks would result in ∆ OCS at the level of 4.25%, ∆ PM at the level of 0.177%. These changes, while maintaining the original ROC level, would have an impact on the selling price difference ∆ SP at the level of 2.8%. This means that in the calculation, it is necessary to add 0.28 euro cents for every €1 of the original selling price. These are the main answers to the study's research question. Quantification of the possibility of calculating the economic risks in question is quite complex and depends on the specific circumstances of the case, including the degree of disability of the employee, his age, income, and other factors. Therefore, it is necessary to consider our proposals mainly as methodological procedures for the application of the calculation of the risks of occupational diseases, and it will be necessary to adapt them to the real conditions of each company.

4. CONCLUSION AND DISCUSSION

The basis for the effective assessment and minimization of risks to endangered workers in the work process is a complete understanding of the performed activities and the resulting risks, work regime, behavior of workers, and the level of safety and health protection at work in the given entity. Insufficient protection against risks in the process of wood chip production primarily stems from inadequate financial resources in forestry activities and subsequent lack of qualified labor. Safety regulations and technological procedures are knowingly and unknowingly violated. The risk of occupational diseases and work-related injuries has largely been shifted from organizations to subcontracting companies. Recognition of occupational diseases is possible only for employees. Therefore, individuals engaged in independent income-generating activities are discriminated against in this legislative regard. Regulatory authorities are understaffed and underfunded, limiting their ability to carry out necessary inspections. It is therefore essential to increase the awareness and occupational consciousness of workers themselves so that they comply with legislative regulations and use personal protective equipment out of their own interest.

Due to deficiencies in legislation and regulatory oversight regarding biomass heating plants, it appears that technical regulations for their construction and operation are incomplete, as stakeholders and responsible parties do not have sufficient information about many of the risks associated with their operation. The following recommendations arise from the results of this work:

- Update and enhance legislation: It is necessary to review and update existing legislation related to biomass heating plants to ensure that technical regulations and safety standards are sufficiently accurate and reflect the current risks of their operation.
- Improve regulatory oversight: Investment in personnel and financial resources for regulatory authorities is essential to ensure effective and regular inspections that could identify potential risks and ensure compliance with regulations.
- Education and information dissemination to stakeholders: Strengthening awareness and education among stakeholders, including operators of biomass heating plants, about risks and safety measures is crucial for the prevention and minimization of risks.
- Implementation of an information collection and exchange system: Establishing a mechanism for collecting and exchanging information among operators of heating plants, regulatory authorities, and other relevant entities could enhance the ability to respond to new risks and challenges.
- Research into new technologies and solutions: Investment in research and development of new technologies and solutions in the field of biomass heating plants could contribute to improving the efficiency and safety of this form of energy production.

These recommendations aim to increase efficiency and safety in the operation of biomass heating plants through the improvement of legislation, strengthening regulatory oversight, and promoting education and innovation in this field.

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REFERENCES

1. Act. No. 437/2004 The Act on Compensation for Pain and Compensation for Impairment of Social Performance and on the Amendment. Slovak Republic.
2. Act. No. 461/2003 The Act on Social Insurance.
3. Act. No. 311/2001 The Labour Code.

4. Barontini, M.; Crognale, S.; Scarfone, A.; Gallo, P.; Gallucci, F.; Petruccioli, M., Pesciaroli, L., Pari, L. (2014): *Airborne fungi in biofuel wood chip storage sites*. In: International Biodeterioration and Biodegradation, Vol. 90, p. 17-22. DOI: 10.1016/j.ibiod.2013.12.020.
5. European Court of Auditors. (2018). *Renewable energy for sustainable rural development: significant potential synergies, but mostly unrealized*. Official Journal of the European Union, Special Report No 5/2018, Luxemburg, 102 p. URL:https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018SA0005(01).
6. Gejdoš, M.; Lieskovský, M. (2024): *Overview of Health and Safety Risks in the Process of Production and Storage of Forest Biomass for Energy Purposes—A Review*. In: Energies, Vol. 17, 1064. DOI: 10.3390/en17051064.
7. González-García, P.; Alonso-Sardón, M.; Rodríguez-Alonso, B.; Almeida, H.; Romero-Alegría, A.; Vega-Rodríguez, V.J.; López-Bernús, A.; Muñoz-Bellido, J.L.; Muro, A.; Pardo-Lledías, J.; Belhassen-García, M. (2022): *How Has the Aspergillosis Case Fatality Rate Changed over the Last Two Decades in Spain?* In: Journal of Fungi, 8(6): p.576. DOI: 10.3390/jof8060576.
8. Král, B. et al. (2018). *Manažerské účetnictví. 4. rozšířené a aktualizované vydání*. Praha: Management Press, 792 p.
9. Nariadenie vlády č. 356/2006 Z.z. o ochrane zdravia zamestnancov pred rizikami súvisiacimi s expozíciou karcinogénnym a mutagénnym faktorom pri práci
10. Národné centrum zdravotníckych informácií. (2023): *Choroby z povolania alebo ohrozenia chorobou z povolania v Slovenskej republike*. URL: https://www.nczisk.sk/statisticke_vystupy/tematicke_statisticke_vystupy/choroby_povolania_aleb o_ohrozenia_chorobou_povolania/Pages/default.aspx.
11. Otero, C.; Arredondo, C.; Echeverría-Vega, A.; Gordillo-Fuenzalida, F. (2020): *Penicillium spp. mycotoxins found in food and feed and their health effects.* In: World Mycotoxin Journal, 13(3), pp. 323-343. DOI: 10.3920/WMJ2019.2556.
12. Pai, S.J.; Carter, T.S.; Heald, C.L.; Kroll, J.H. (2022): *Updated World Health Organization Air Quality Guidelines Highlight the Importance of Non-antropogenic PM2.5*. Environmental Science & Technology Letters 9: pp. 501–506. h ps://doi.org/10.1021/acs.estle .2c00203.
13. Popesko, B.; Papadaki, Š. (2016). *Moderní metody řízení nákladů: jak dosáhnout efektivního vynakládání nákladů a jejich snížení.* Praha: Grada Publishing, 2016. 264 p.
14. Potkány, M.; Krajčírová, L. (2015). *Kalkulácie a rozpočty.* Zvolen: Technická univerzita vo Zvolene, 197 p.
15. Statistical Office of the Slovak Republic. (2022). Yearbook of industry of the SR 2022 Headquarters Bratislava. https://slovak.statistics.sk/
16. Steinbrink, J.M.; Miceli, M.H. (2021): Mucormycosis. In: Infectious Disease Clinics of North America, 35(2): pp. 435-452. DOI: 10.1016/j.idc.2021.03.009.
17. National health information centre (2024): 525 Cases of occupational diseases increased in 2022. URL: https://www.nczisk.sk/Aktuality/Pages/NCZI-V-roku-2022-pribudlo-525-pripadov-chorob-z-povolania.aspx.

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IMPACTS OF THE GREEN TRANSITION ON THE FOREST-BASED SECTOR IN THE CZECH REPUBLIC

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Abstract: The paper deals with the impact of selected strategic national-level documents on management and sustainability in the forest-based sector. The core methodological approach is the content analysis that is applied to the Czech documents related to the forest bioeconomy. Considerable attention is paid to the coherence of the measures of the National Research and Innovation Strategy for Smart Specialisation of the Czech Republic 2021-2027 (RIS3) and requirements/needs of the actors in the forest-based sector. RIS3 strategy has strong national and regional dimensions and emphasize the key topics related to the green transition. It explicitly mentions the climate change, circular economy, low-carbon economy, ecosystems, and environmental protection that are pivotal topics of sustainable forest-based sector in future. The paper also takes account of effects of the territorial nature protection on forest management and wood-processing sector in the Czech Republic.
Keywords: bioeconomy, strategies, ecosystem services, nature protection

1. INTRODUCTION

The Czech Republic, like many other European countries, has faced several social, economic, and environmental challenges in recent years. Some of them are caused by long-term consequences of human actions, some have arisen as a reaction to short-term or current problems or disturbances (covid pandemic, bark beetle outbreak). The forest-based sector and, indirectly, the entities operating in it (forest owners, forest managers, businesses, forest visitors, etc.) must also adapt to these external influences.

The transformation of economies towards a more sustainable use of resources can be referred to as the *Green Transition*. A related concept is *Green Growth* (OECD, 2018), which is the promotion of economic growth while continuously providing natural resource and environmental services. The "greening" of policies and practical approaches to the transformation of economies and ways of thinking can also be applied to the forest-based sector, especially with the growing importance of forests and the ecosystem services they provide, which are not only positively valued by society (changing and growing societal demand) but also enable or support the development of other downstream economic sectors.

Forests contribute significantly to meeting climate policy objectives, not only through the absorption of CO_2 in forests but also in wood products. The management of Czech forests has long been marked by discussions and disputes between forest owners and nature conservation authorities. In 2024, a forestry research project aimed at the impacts of territorial nature protection on the management of forest owners and the wood-processing sector funded by the National Agency for Agricultural Research (Ministry of Agriculture of the Czech Republic) starts. The topic has emerged from the research needs for the Ministry of Agriculture in science, research, and innovation competition in the key area of bioeconomy (eAgri, 2023). The results of the project, coordinated by the Czech University of Life Sciences, will be, among others, used to support the state administration and support state policy in the agricultural sector. The authors of this article are members of the research team of the mentioned project.

The paper deals with the connection between strategic documents, measures, and activities currently underway in the forest-based sector in the Czech Republic, which have the potential to influence the actions of key actors in the sector, including the specific target group, which are Czech forest owners.

2. METHODS

The methodological approach is based on the content analysis applied to selected documents that are in line with the following criteria:

- Direct relevance to the forest-based sector,
- Connection to the current challenges of the forest-based sector,
- National level relevance (Czech document issued by official authority in the Czech Republic),
- Document being „in force“(temporal validity of the document, still valid in 2024),
- Public availability of the document (e.g., available on web pages on respective national bodies (ministries, government, etc.).

The documents were found in Czech language and subsequently subjected to content analysis with relevant key words (forestry, wood, bioeconomy, circular economy, green economy, carbon), with priority connection to the climate change to perform a qualitative analysis in line with the goal of the paper. Similar methodological approach was already used in some other works, e.g., by Palátová (2023). The selected documents consider coherence with relevant European strategies.

3. RESULTS

3.1 Bioeconomy and the Forest-Based Sector

European bioeconomy includes various sectors of economy, including those that are contributing to the green solutions, using renewable resources, effective and new methods of utilization of waste and residues (e.g., after logging), and application of new technologies and innovative products. There is a strong link to sustainability, but also some other theoretical concepts are very closely connected. Some countries even refer to bioeconomy having the same meaning as green economy, e.g., in the case of Slovakia (Palátová et al., 2022) or closely connecting topics of bioeconomy, circular and green economy, such as it is the case in Thailand (Rinn et al., 2024). Some authors refer to green economy as an umbrella topic including aspects of both circular economy and bioeconomy, but all concepts are targeting economic, environmental, and social goals (D´Amato et al., 2017).

The bioeconomy is a practical approach to address current socio-economic challenges and, from the perspective of the forest-based sector, promotes practical sustainable solutions. In addition to promoting innovative processing methods including biotechnology (biomass and its processing, but also the use of innovative technologies in traditional sectors of the economy, which includes the timber industry), it also supports overarching objectives such as finding alternatives to non-renewable resources (here the forest-based sector, and thus its related sectors of the economy, has considerable potential), but it also promotes sustainable value chains, mitigates the impacts of climate change and takes into account the circular economy (MoA, 2019). While these approaches may be significantly emphasized especially at the macroeconomic level, the practical impact of each measure affects all key actors in decision-making, science and research, and business, and indirectly consumers. The objectives of the European Bioeconomy Strategy include sustainable management of natural resources, reducing dependence on fossil resources, adaptation to climate change (EC, 2018).

3.2 Green Economy and Green Jobs

Green economy is an alternative to current economic model with strategical emphasis on improvement of human well-being and building social equity whole reducing environmental risks (UNEP, 2024). Green economy is built up on 5 principles (Green Economy Coalition, 2020):

1. Wellbeing
2. Justice
3. Planetary boundaries
4. Efficiency and sufficiency
5. The good governance

Job positions that are offered within the green economy are called as *green jobs*. These jobs aim the environment to benefit by preserving and restoring the environment, no matter if they are in the traditional sectors or new sectors (ILO, 2016). In the matter of sustainability issues, green jobs help to promote several SDGs (1,4,5,6,7,8,12 and 17). Usually, green jobs help to improve efficiency in energy and raw materials, limit GHG emissions, minimize waste and pollution, protect, and restore ecosystems and supports adaptation to climate change (ILO, 2016). Green jobs are usual in economic sectors closely connected to environment. One of the key-term used is also the low-carbon economy, that is one of the key targets of the European Green Deal, since its goal is to make Europe climate neutral by 2050 (EGD, 2020; ILO, 2016).

Green jobs potential is estimated for growth including jobs creation in rural areas. It is also connected with so-called just transition where workplaces for everyone are supported and with social protection (ILO, n.d.) Workplaces in green economy in line with the transformation of national economies are needed to be supported by substantial change in the knowledge base. The overlap, need for more knowledge and holistic approach might impose a challenge for the educational system.

Jobs in the forestry sector also have the potential to meet the terminological definition of a "green job". On the one hand, there are the potential and opportunities associated with green solutions that are also applicable in the forest-based sector, and on the other hand, there are the potential limitations that arise from legislative or strategic materials. For forest owners, the most important information is the information aimed at possible restrictions on the use of their property, in particular restrictions on management.

3.3 Current state of territory protection in the Czech Republic

In the Czech Republic, the specific protection of the territory is applied on an area of almost 3 million hectares and is legislatively enshrined in the Act on Nature and Landscape Protection (114/1992 Coll.) and decrees (395/1992 Coll., 45/2018 Coll.). Specially protected areas are divided into large-area (national parks and protected landscape areas) and small-area (national nature reserves, national natural monuments, nature reserves, nature sanctuaries). The majority of the area of national parks, national nature reserves and national natural monuments is administered by the Nature Conservation Agency of the Czech Republic (an organisational unit of the state carrying out state administration, information and awareness-raising activities, financial compensation, research, expert opinions and other activities on behalf of the Ministry of the Environment). Due to the Czech Republic's membership in the EU, the NATURA 2000 system with 41 bird areas and 1112 sites of European importance has also been defined (AOPK, 2024).

In the case of restrictions on management, owners may be compensated for restrictions on in specially protected areas, NATURA 2000 sites, commemorative trees, protected plants, animals and minerals; for measures within territorial systems of ecological stability and on the basis of decisions of state nature protection authorities, binding opinions and agreements and is paid from the state budget. They fall under the competence of the Ministry of the Environment. The Ministry of Agriculture does not provide mandated payments related to nature protection, but provides subsidy instruments at the European level (agri-environmental and forest-environmental payments provided under the Common Agricultural Policy and Rural Development Policy).

3.4 Restrictions on forest owners in the Czech Republic

The forest cover in the Czech Republic is 37.1%, covering 2 680 372 hectares of 3 categories - production, protective, and special purpose forests (eAGRI, 2023). Production forests account for almost 75% of this area. Certain forms of restrictions apply mainly to protective and special purpose forests; certain restrictions may also be imposed on the owner in production forests. These restrictions result, for example, from the occurrence of NATURA 2000 areas on forest property - these are Special Protection Areas or Sites of Community Importance, Natura 2000 sites designated according to the EU directives on habitats and birds. The forest owners in the Czech Republic form a heterogeneous structure, 71.79% are public forests (state, municipal and urban), private forests make up 28.21% (legal persons, church, cooperatives, physical persons). The basic rules of management are determined by the Act on Forests (289/1995 Coll.), but they are also based, for example, on voluntary initiatives (PEFC or FSC forest certification). Priority restrictions for the owner are determined by the law on Nature and Landscape Protection (114/1992 Coll.), but also by European regulations concerning the environment and landscape. Other constraints may result from the European regulations relating to the environment and landscape or as a consequence of objectives and measures stated in strategic documents. Those primarily linked to the climate change theme are those listed in Table 1.

3.5 Czech Strategies

Table 1 summarizes the overview of the relevant document that are later presented.

Table 1. Summary of strategies

Strategy	Validity	Administration
Research and Innovation Strategy for Smart Specialisation	2021-2027	Ministry of Industry and Trade
National Recovery Plan	2021-2026 (update 2023)	Ministry of Industry and Trade (NextGeneration EU)
National Action Plan for Adaptation to Climate Change	2021-2025	Ministry of Environment

3.4.1. RIS3 (Research and Innovation Strategy for Smart Specialisation)

Climate and environment are one of the so-called identified megatrends, more specifically climate change, ecosystem degradation and environmental protection. Along with new technologies, depletion of natural resources, demographic change and urbanisation, climate change is one of the key trends. The RIS3 National Strategy includes the Green Technologies, Bioeconomy and Sustainable Food Resources domain, which includes sustainable agriculture and forestry in addition to climate change as mentioned above. The implementation of the national RIS3 strategy is one of the conditions for drawing on EU funding (RIS3, 2024).

3.4.2. National Recovery Plan

The National Recovery Plan is a strategic document that enables the application for funding from The Recovery and Resilience Facility (European Commission). It contains specific measures aimed at nature conservation and climate change adaptation, including building climate resilient forests (deadline: 9/2024) and water retention in the landscape (3/2024). These measures target both legislative changes (modification of the Forestry Planning Decree 84/1996 Coll.) and project-oriented activities, where water retention in the landscape is in line with the National Action Plan for Adaptation to Climate Change as well as the EU Drought Strategy. One of the components of the National Recovery Plan also includes targeted adaptation of aquatic, non-forest, and forest ecosystems to climate change, with deadline at the end 2025 (NPO, 2023).

3.4.2. National Action Plan for Adaptation to Climate Change

The National Action Plan for Adaptation to Climate Change is an application document of the Strategy for Adaptation to Climate Change in the Czech Republic. It covers the period 2021-2025 and is in line with the EU Adaptation Strategy (from 2013). Strategic objective 2 focuses on ecological stability and the provision of ecosystem services of forests, with an emphasis on preventing land degradation and strengthening the natural water regime (management practices, game status, gene pool, water retention in the landscape, etc.). Cross-cutting measures include payment for ecosystem services, green budgeting, conservation, ecosystem services and awareness raising.

Relevant for the forestry sector is the inclusion of the Concept of the State Forestry Policy until 2035 (from 2020), the Strategy of the Ministry of Agriculture of the Czech Republic with a view to 2030 (from 2016).

From the above, the expected impacts of the greening of the economy on the forestry and logging sector include:

- Change in the perception of forestry in the Czech Republic
- The need to actively communicate the ongoing changes in the forestry sector to the public
- Support the role of forestry pedagogy
- Promote informal and experiential learning
- Promote the development and maintenance of new competences among forest owners and forestry sector workers
- To consider the change in education in incorporating interdisciplinarity, incorporating innovation and good practice examples
- Change in legislation
- The increasing role of standardisation and certification
- Supporting control mechanisms for monitoring and evaluation of public funds directed to the forestry sector

Among the key actors, the measures directly affect forest owners, professional forest managers, forestry service providers, processing enterprises, public administration and professional promoters, educational institutions including students, certification and authentication authorities, science, and research.

4. DISCUSSION

The paper identified concepts and strategies related to the green approach. Usually these concepts are mainly environmental, their meaning is also relevant in the forestry and wood sector. A key concept is climate change, to which not only forest owners, but also actors in the downstream processing and value chain, and in a broader perspective, society, must adapt. With the increasing level of knowledge and changes in society, the importance and perception of forests is also changing, including in the direction of supporting ecosystem services, where the most important service in the Czech Republic so far - production (especially wood production) is being supplemented by other services, or a mix of services provided by healthy forest ecosystems. This includes not only production, but also regulating, cultural and supporting (e.g., see MEA classification, 2005). With increased interest in ecosystem services, one of the necessary issues to address is the issue of payments for ecosystem services (PES). These payments are mainly incentive and preventive in principle. It should be noted that, for example, the ecosystem services payment scheme is still a relatively new topic in the Czech Republic. As stated by Wunder (2015) "*PES involve voluntary transactions between users and service providers that are contingent on agreed rules for managing natural resources to generate services"*. PES sometimes includes compensation payments, which compensate for legal restrictions on property rights and serve to apply no or differentiated forest management. The potential expansion of PES carries the risk of increasing constraints on forest owners, including affecting the availability and marketability of timber raw material, and thus affecting the forest-based value chain.

Consensus on the application of payments for ecosystem services is key, not least because current options for forest use and benefits, e.g. including NWFP, allow Czech visitors to enter the forest without restrictions, which may lead to a congestion effect. The extreme increase of visitors is then also a challenge for forest management (Jarský et al., 2022; Derks et al., 2020) and forest owners. The issue of setting up a payment mechanism for ecosystem services is at the forefront of the priorities addressed also within the project QK23020008 (2023-2025, financed by Ministry of Agriculture of the Czech Republic), also due to the necessary change of the forest law that would allow such payments. The motivation for the introduction of payments is to support the fulfilment of forest ecosystem services in the Czech Republic, including payments for intensification payments. These payments would be made from the state budget.

It is necessary to state that, despite the apparent fragmentation of the topics mentioned in the strategic materials, it is clear after their closer examination that together they form a complex system with a great potential for synergy. Most of the Czech strategic materials are also directly linked to strategic and conceptual materials at the European level. This supports the strategic focus within the development of the entire forestry and wood sector and beyond. For a comprehensive evaluation, it would be appropriate to supplement the analysis with documents that relate to related economic sectors, or to include those that have an interdisciplinary overlap (Strategic Framework Circular Czechia 2040, strategy for biodiversity, energy policy, waste management policy, etc.) The success of the implementation of strategies depends also on improving the information and knowledge base of all relevant actors, and it is necessary to support the connection of the results of the solutions of scientific and research projects with practice.

5. CONCLUSION

"Greening" is a hallmark of contemporary economies. The contribution dealt with the influence of selected strategic documents on the forestry and wood sector in the Czech Republic. The selected strategies were viewed through the lens of content analysis. The evaluated documents show their essential multidisciplinary character. In addition to the measures that result from the strategies, restrictions resulting from the protection of the territory and/or restrictions that limit forest management are also mentioned. The owners and managers of the given territories are primarily affected by these restrictions, the effects of these restrictions can be significant, sometimes even societal. However, they do not only concern the affected target groups, but also specific topics (perception, education, legislation, control mechanisms in the forestry and timber sector).

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REFERENCES

1. AOPK (2024). Ochrana území. URL: https://www.nature.cz/ochrana-uzemi
2. CZSO (2020). HDP, národní účty. URL: https://www.czso.cz/documents/10180/150808213/3202032105_hdp.pdf/8955d30e-b879-4c13-a496-a10d754abc23?version=1.3#:~:text=Pr%C5%AFmysl%20hraje%20v%20%C4%8Desk%C3%A9%20ekonomice%20v%C3%BDznam-nou%20roli%20a,v%20roce%202020%20tvo%C5%99il%20jen%202%2C1%20%25%20HPH.
3. D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B.D., Toppinen, A. (2017*). Green, circular, bio economy: a comparative analysis of sustainability avenues*. J. Clean. Prod., 168, pp. 716-734.
4. eAGRI (2023): Výzkumné potřeby Ministerstva zemědělství pro veřejnou soutěž ve výzkumu, vývoji a inovacích v roce 2023. URL: https://eagri.cz/public/portal/mze/poradenstvi-a-vyzkum/vyzkum-a-vyvoj/narodni-agentura-pro-zemedelsky-vyzkum/program-aplikovaneho-vyzkumu/verejna-soutez-vyhlasena-v-roce-2023/vyzkumne-potreby-ministerstva
5. eAgri (2023). Zpráva o stavu lesa a lesního hospodářství 2022. URL: https://eagri.cz/public/portal/-a30268---rWtfkQZD/zprava-o-stavu-lesa-a-lesniho-hospodarstvi-ceske-republiky-v-roce-2022-strucna-verze?_linka=a540692
6. EC (2018). Updated Bioeconomy Strategy 2018. URL: https://knowledge4policy.ec.europa.eu/publication/updated-bioeconomy-strategy-2018_en
7. EGD (2020). The European Green Deal. URL: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
8. Green Economy Coalition (2020). The 5 Principles of Green Economy. URL: https://www.greeneconomycoalition.org/news-and-resources/the-5-principles-of-green-economy
9. ILO (2016). What is a green job? URL: https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm
10. ILO (n.d.). SGD Note. Green jobs. URL: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---integration/documents/genericdocument/wcms_561751.pdf
11. Jarský, V.; Palátová, P.; Riedl, M.; Zahradník, D.; Rinn, R.; Hochmalová, M. *Forest Attendance in the Times of COVID-19—A Case Study on the Example of the Czech Republic* (2022). Int. J. Environ. Res. Public Health, 19, 2529.

12. MEA (2005). Millennium Ecosystem Assessment. URL: https://www.millenniumassessment.org/en/index.html
13. MoA (2019). Koncepce biohospodářství v ČR z pohledu Ministerstva zemědělství (2019–2024) [Bioeconomy concept in the Czech Republic from the perspective of the Ministry of Agriculture (2019–2024)]. URL: http://eagri.cz/public/web/mze/poradenstvia-vyzkum/vyzkum-a-vyvoj/koncepce-a-strategie/koncepcebiohospodarstvi-v-ceske.html
14. MoENV (2023). Národní akční plan adaptace na změnu klimatu. URL: https://www.mzp.cz/cz/narodni_akcni_plan_zmena_klimatu
15. NPO (2023). Národní plán obnovy. URL: https://www.ris3.cz/analyzy-a-dokumenty/zakladni-dokumenty
16. OECD (2018): What is green growth and how can it help deliver sustainable development?URL:https://www.oecd.org/greengrowth/whatisgreengrowthandhowcanithelpdeliversustainabledevelopment.htm#:~:text=Green%20growth%20means%20fostering%20economic%20growth%20and%20development,growth%20and%20give%20rise%20to%20new%20economic%20opportunities.
17. Palátová, P. (2023). *Projections of the European Green Deal into national strategic documents in the Czech Republic: the case of forestry* (International IUFRO Conference Deal for Green? Contribution of managerial economics, accounting, and cross-sectoral policy analysis to climate neutrality and forest management), Ljublana, Slovenia, p. 80-85, https://doi.org/10.20315/SilvaSlovenica.0022.28.
18. Palátová, P., Purwestri, R.C., Marcineková, L. (2022). *Forest bioeconomy in three European countries: Finland, the Czech Republic and the Slovak Republic*. International Forestry Review, 24(4), pp. 594-606.
19. Riedl, M.; Jarský, V.; Palátová, P.; Sloup, R. *The Challenges of the Forestry Sector Communication Based on an Analysis of Research Studies in the Czech Republic.* Forests, 10, 935.
20. Rinn, R., Jankovský, M., Palátová, P., García-Jácome, S.P., Sharp, A., Wangpakapattanawong, P., Lovrić, N., Van, M.V., Nhat, M.D.T., Ninchaleune, B., Chanthavong, I., Doungmala, K. (2024). *Bioeconomy in countries of the Mekong region: Stakeholder understanding and perceptions in Thailand, Vietnam, and Laos*, Forest Policy and Economics, Volume 162, 103190.
21. RIS3 (2024). RIS3. Základní dokumenty. URL: https://www.ris3.cz/analyzy-a-dokumenty/zakladni-dokumenty
22. UNEP (2024). About Green Economy. United Nations Environment Programme. URL: https://www.unep.org/explore-topics/green-economy/about-green-economy.
23. Wunder, S. (2015): *Revisiting the concept of payments for environmental services*. Ecol. Econ., 117, pp. 234-243.

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THE IMPORTANCE OF NON-EU-27 COUNTRIES IN SUPPLYING THE EU-27 MARKET WITH WOODEN PALLETS

Slavica Petrović

Abstract: This study analyses the supply of wooden pallets to the EU-27 market, paying particular attention to the importance of non-EU-27 countries as suppliers. The importance of South-East European countries, as non-EU-27 countries, in the supply of wooden pallets to the EU-27 market was specifically analyzed. The study focuses on the period 2002-2022. In addition to the trade volume, the import value of wooden pallets into the EU-27 from non-EU-27 countries was also analyzed. To a limited extent, the types and characteristics of wooden pallets most commonly used on the EU-27 market were analyzed. Wooden pallets are subject to the EU Timber Regulation, i.e. the new EU Deforestation Regulation, which was adopted last year.
Keywords: wooden pallets, EU-27 market, import, non-EU countries, standards.

1. INTRODUCTION

According to the ISO 445:2013, pallets are „rigid horizontal platforms of minimum height suitable for handling by pallet trucks and/or forklift trucks and other appropriate handling equipment and used as a base for the assembly, loading, storage, handling, stacking, transportation or displaying of goods and loads". In addition to wood, pallets are also made of plastic (virgin and recycled plastic), metal, cardboard and wood-polymer composites (Deviatkin et al., 2002). In addition to the ISO 445 standard, the most important standards that specify the properties of wooden pallets, are as follows: ISO 15629:2002, ISO 18333:2014, ISO 18334:2010 and ISO 18613:2014.

According to the Fredonia Group study (2020), "wooden pallets are by far the most common type of pallet, accounting for 92% of unit demand and 83% of sales in value terms in 2019", while the share of plastic pallets is significantly lower and the shares of pallets made from other materials are insignificant.

Wooden pallets exported to the EU-27 market are subject to the European Union Timber Regulation (EUTR) (European Parlament and the Council of the European Union, 2010). However, in 2023, the EU Deforestation Regulation was adopted (EUDR). "The Deforestation Regulation is part of the European Green Deal initiative and aims to ensure that EU consumption does not contribute to global deforestation and forest degradation arising from agricultural expansion linked to the relevant commodities" (Global Compliance News, 2024). According to Article 37(1) of the EUDR, "Regulation (EU) No 995/2010 is repealed with effect from 30 December 2024" (European Parlament and the Council of the European Union, 2023). Paragraph 2 of the same Article of the EUDR states: "Regulation (EU) No 995/2010 shall continue to apply until 31 December 2027 to timber and timber products that were produced before 29 June 2023 and placed on the market from 30 December 2024" (European Parlament and the Council of the European Union, 2023). Annex I of the EUDR lists all types of timber and timber products to which the new regulation applies.

2. METHODOLOGY

The analysis of the market supply with wooden pallets in the EU-27 was carried out on the basis of data from the Eurostat database. The data for wooden pallets are recorded in Chapter 44 of the Eurostat database: "Wood and articles of wood; wood charcoal", in section 441520: "Pallets, box pallets, and other load boards, of wood; pallet collars of wood (excl. containers specially designed and equipped for one or more modes of transport)". In this section, data for import/export of wooden pallets and pallet colars are recorded together under HS code 44152020: Pallets and pallet collars, of wood. (https://ec.europa.eu/eurostat/comext/newxtweb/setupdimselection.do#). As a result of such record keeping, the results presented in chapters 3.1., 3.2. and 3.3. are a summary for pallets and collars. Apart from the value indicators, the data for the import/export of wooden pallets and pallet collars are also recorded in kilograms in the Eurostat database. The explanations in the analysis of the market supply in the EU-27 rely on the assumption that the mass of wooden pallets and collars is equal to the mass of wood. This is, of course, not the case since they contain metal parts. However, as the Eurostat database combines data for pallets and collars, it is not possible to accurately determine the shares of wood or metal in the total mass of pallets and collars imported into the EU-27.

3. RESULTS AND DISCUSSION

This chapter presents the results of market supply research for wooden pallets and collars in the EU-27 for the period 2002-2022. The market supply in the EU-27 from member states (intra EU-27) and imports from non-EU countries (extra EU-27) were analyzed. The main non-EU countries supplying this market were analyzed, with particular attention paid to the role of South-East European countries in supplying this market. In addition, an analysis of the market in the EU-27 was carried out in terms of the most commonly used types of wooden pallets and their characteristics, as well as the market in the South-East European countries.

3.1. EU-27 market supply with wooden pallets and collars

In the period 2002-2022, the EU-27 increased total imports (intra EU-27 import + extra EU-27 import) of wooden pallets and collars from 2.5 million tons of wood (2002) to 5.6 million tons of wood (2022) (Figure 1) (Eurostat, 2024). In all years of the analyzed period, certain EU-27 members were the most important suppliers of wooden pallets and collars to the EU market. The supply of the EU-27 market by EU countries increased from 2.2 million tons of wood (2002) to 4.5 million tons of wood (2022), while in the same period the supply by non-EU-27 countries increased from 171260 tons of wood (2002) to 1.04 million tons of wood (2022) (Eurostat, 2024). In the period 2002-2022, the EU-27 doubled the imports of wooden pallets and collars from EU member states, while imports from non-EU-27 countries increased sixfold. In 2002, the EU-27 met 93.0 % of its market demand with imports from member countries and 7.0 % with imports from non-EU countries, while in 2022 the ratio was 81.4 %:18.6 % (Eurostat, 2024).

In the period 2002-2022, the total import value of wooden pallets and collars into the EU-27 (intra EU-27+extra EU-27) increased from € 0.6 billion to € 3.33 billion (Eurostat, 2024). EU-27 imports from its own Member States increased from € 562.5 million (2002) to € 2.8 billion (2022), i.e. almost fivefold (Eurostat, 2024). At the same time, the value of imports of wooden pallets and collars from non-EU countries into the EU-27 increased from € 42.3 million (2002) to € 524 million (2022), i.e. it increased 12.4 times (Eurostat, 2024). In 2002, the share of imports from EU-27 countries in the value structure was 93 % and the share from non-EU countries accounted for 7.0 %, while the ratio in 2022 was 84.3 %:15.7 % (Eurostat, 2024).

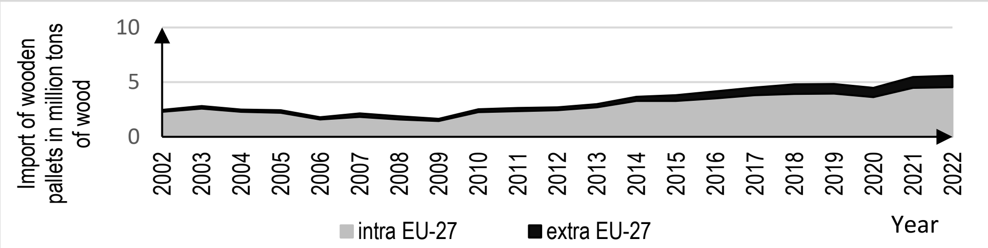

Figure 1: Market supply of wooden pallets and collars in the EU-27 in the period 2002-2022 (source: Eurostat, 2024)

3.2. The main non-EU countries for supplying the EU-27 market

Ukraine, Belarus, Norway, the UK, Switzerland and Russia are the main suppliers of wooden pallets and collars to the EU-27 market (Figure 2) (Eurostat, 2024). Since 2002, when it imported 154000 tons of wood, the EU-27 increased its imports from these countries to 894211 tons of wood in 2022 (Eurostat, 2024). In 2002, EU-27 imports from the above countries accounted for 89.9 % of imports from non-EU-27 countries, with Belarus accounting for 54.4 %, the UK 17.8 %, Russia 8.5 %, Ukraine 4.4 %, Switzerland 3.5 % and Norway 1.3 % (Eurostat, 2024). In the period up to 2022, there were significant changes in the supply of wooden pallets and collars from non-EU countries to the EU-27 market. The first change occurred in 2015, when Ukraine replaced Belarus as the largest supplier on the EU-27 market and maintained this position until 2022. Even more significant changes occurred in 2022, when the EU-27 reduced imports from Belarus by 63.2 % and from Russia by 48.3 %, and increased imports from Ukraine by 53.1 % and from the UK by 51.6 % (Eurostat, 2024). In absolute terms, the EU-27 increased its imports of wooden pallets and collars from the six countries listed in 2022 compared to 2021. However, the share of imports from the largest suppliers in imports from non-EU countries fell to 85.9% in 2022, with Ukraine's share accounting for 49.2%, Norway's for 10.2%, the UK's for 9.9%, Belarus' for 6.9%, Switzerland's for 5.8% and Russia's for 3.9% (Eurostat, 2024).

The value of imports of wooden pallets and collars into the EU-27 from the six largest suppliers increased from € 38 million (2002) to € 437.5 million (2022) (Eurostat, 2024). During the analyzed period, the import value of wooden pallets and collars from Ukraine increased the most. It increased from € 1.4 million in 2002 to € 137.7 million in 2021 and € 263.7 million in 2022 (Eurostat, 2024). At the same time, the value of imports from Belarus increased from €

15.2 million in 2002 to a record € 61.2 million in 2021 and then fell to € 28.7 million in 2022 (Eurostat, 2024). The same trend was registered for the import value from Russia, which increased from € 3.0 million in 2002 to a record € 32.8 million in 2021, and then fell to € 19.9 million in 2022 (Eurostat, 2024).

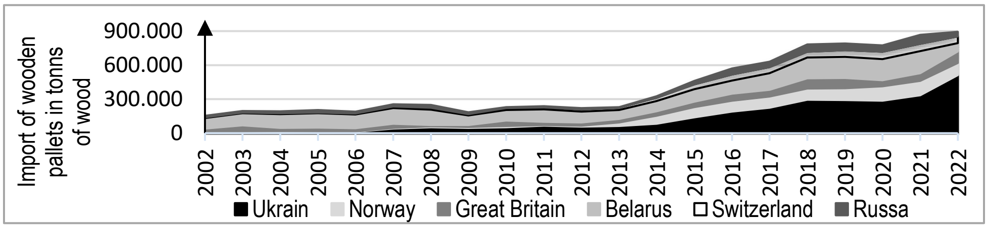

Figure 2. The major non-EU countries that supplied wooden pallets and collars to the EU-27 market in the period 2002-2022 (Source: Eurostat, 2024)

3.3. The importance of SEE countries in supplying the EU-27 market

In 2002, the imports of wooden pallets and collars into the EU-27 from the countries of South-Eastern Europe, including Bosnia and Herzegovina, Serbia, Albania, Montenegro and North Macedonia, accounted for 3.7% of imports from non-EU countries. In 2022, the EU-27 imported 65,500 tons of wood from SEE countries, which accounted for 6.3 % of imports from non-EU countries. The changes in trade flows for wooden pallets and collars that occurred on the European market in 2022 had a positive impact on the supply of these products from the countries of South-Eastern Europe to the EU-27 market. Bosnia and Herzegovina and Serbia are the most significant SEE countries for the supply to the EU-27 market (Figure 3). Since 2002, when the EU-27 imported 6,000 tons of wood from Bosnia and Herzegovina, it has increased its imports to 27,717 tons of wood. EU-27 imports from Serbia were slightly lower in 2022, amounting to 20,660 tons of wood, while imports from Albania amounted to 10,011 tons of wood, from North Macedonia 4,338 tons of wood and from Montenegro 2,774 tons of wood.

The value of imports of wooden pallets and collars from SEE countries into the EU-27 increased from € 1.2 million (2002) to € 37.4 million (2022). In 2022, the value of EU-27 imports of wooden pallets from B&H amounted to € 15.4 million, from Serbia € 13.5 million, from Albania € 5.0 million, from North Macedonia € 2.0 million and from Montenegro € 1.4 million (Eurostat, 2024).

3.4. The wooden pallets market in the EU-27

The market of wooden pallets in the EU-27 is the market for EPAL pallets. Their quality is certified and approval for the use of the EPAL designation is provided by the European Pallets Association - EPAL. In addition to EPAL 1, i.e. the EPAL Euro pallet, as it is also known, the association certifies the quality of EPAL 2 pallets, EPAL 3 pallets, EPAL 6 half pallets, EPAL 7 half pallets, EPAL box pallets and EPAL CP1, CP2 and CP3 pallets (EPAL, 2024). Since 2019, EPAL Euro pallets have been marked with a QR code. The association certifies not only manufacturers of wooden pallets, but also companies that repair them. The EPAL Euro pallet has the dimensions 800x1200x144mm, a defined number of boards and blocks from which it is made, as well as their dimensions, a precisely defined distance at which the boards and blocks are placed, the number of nails and their position, weight and load capacity of the pallet (EPAL, 2024). The above characteristics are defined for all types of EPAL pallets. In addition to the EPAL designation, the IPPC designation is applied to wooden pallets to confirm that the pallet has been chemically or thermally treated to destroy xylophagous insects (EPAL, 2024). Nowadays, chemical treatment is rarely in use. Thermal treatment means that the wooden pallet has been exposed to a temperature of 56 °C for at least 30 minutes. In addition to the above information, EPAL pallets are marked with the following information: code of the country where the pallet was manufactured, registration number of the authority which conducted the chemical/thermal treatment, treatment method, EPAL control staple, repair marking nail (only present if it is a repaired EPAL pallet), license number, FOR50 (EPAL, 2024: https://www.epal-pallets.org/eu-en/load-carriers/epal-euro-pallet). According to the rules of the Association, unused wooden pallets are classified as "new" and used pallets are classified as quality classes A, B or C. Damaged pallets that and can no longer be used are classified as "not fit for use", while mixed pallets of all types are classified as "unsorted". The quality of the individual classes of wooden pallets is precisely defined. The moisture content of the wood is only prescribed for new pallets and it is up to 22% (EPAL, 2024: https://www.epal-pallets.org/eu-en/translate-to-en-qualitaet-und-tausch/translate-to-en-qualitaetsklassifizierung).

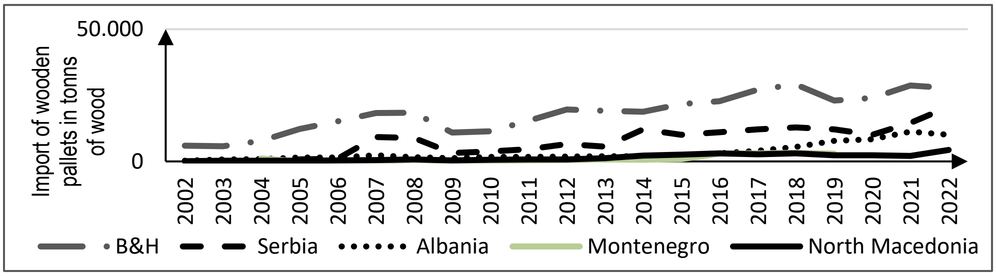

Figure 3: Supply of the EU-27 market with wooden pallets and collars from SEE countries in the period 2002-2022 (source: Eurostat, 2024)

The defects which make professionals declare pallets unsuitable for use are described, in cases when it is necessary for them to be repaired in order to be reused. The average lifespan of wooden pallets is assumed to be 3 to 5 years (Associated Pallets Ltd, 2024).

Wooden pallets that are no longer usable are wood waste and as such they are part of the European Waste Catalog, which was established by the European Commission's Decision 2000/532/EC. In the catalog, wooden pallets are classified in waste category 15, i.e. in subcategory 1501: Packaging. Wooden packaging, including pallets that have not been chemically treated, is classified in waste subcategory 150103, and if it contains hazardous substances, in 150108. In Germany, waste wood is classified into classes AI, AII, AIII and AIV (The Altenstadt Combined Heat and Power plant, 2024). Euro pallets made from solid wood belong to quality class AI, those made from wood-based materials to quality class AII and those made from composite materials to quality class AIII. Chemically untreated and bark-free wooden pallets can be used for the production of wood pellets, briquettes and chips of quality class B as well as for quality classes TW2H-TW2L of thermally treated and thickened wood fuel (Toscano et al., 2023). Chemically untreated and chemically treated wooden pallets without bark can be used for the production of hog fuel and chips for industrial purposes (Toscano et al., 2023).

3.4.1. The wooden pallets market in SEE countries

The supply of wooden pallets from SEE countries to the EU-27 market is determined by the volume of production of new EPAL pallets in these countries. However, the EU-27 not only imports new EPAL pallets, but also used EPAL pallets of certain quality classes as well as elements for new EPAL pallets (Paleta doo, 2024). In addition to EPAL, non-certified wooden pallets are also produced in the South-East European countries in various dimensions according to customer requirements. Such pallets are called disposable pallets, although they can be used more than once. Disposable pallets differ in the number of boards and blocks, load capacity and stability. They are mainly used for transportation within SEE countries that do not belong to the EU. Depending on customer requirements, they can be thermally treated. Instead of designations A, B or C, quality class designations I and II are used in some SEE countries Class I used EPAL pallets have well-preserved mechanical and aesthetic properties, a slightly darker wood color compared to new pallets and minor damage due to forklift manipulation. Class II EPAL pallets have been used for a longer time and therefore have a darker wood color, although their mechanical properties and load-bearing capacity have been preserved.

4. CONCLUSION

In 2002, the EU-27 members supplied their own wooden pallet and collar market with 2.2 million tons of wood, while imports from non-EU countries into the EU-27 amounted to 171,260 tons of wood. In 2022, the supply of the EU-27 market by EU members increased to 4.5 million tons of wood, while imports from non-EU countries increased to 1.04 million tons of wood. In 2002, the EU-27 met only 7% of its demand by importing wooden pallets and collars from non-EU countries, while this share increased to 18.6 in 2022. This clearly shows that non-EU countries are becoming increasingly important in supplying the EU-27 market with wooden pallets and collars. Therefore, it can be deduced that South-East European countries have the opportunity to strengthen their role in supplying the EU-27 market with wooden pallets and, especially after the changes in trade flows which took place in Europe in 2022.

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REFERENCES

1. Deviatkin, I.; Khan M. M. H.; Ernst, E.; Horttanainen, M. (2019): Wooden and Plastic Pallets: A Review of Life Cycle Assessment (LCA) Studies, Sustainability 11 (20),

https://www.researchgate.net/publication/336604166_Wooden_and_Plastic_Pallets_A_Review_of_Life_Cycle_Assessment_LCA_Studies (accessed on 12 January 2024).
2. Toscano, G.; De Francesco, C.; Gasperini, T.; Fabrizi, S.; Duca, D.; Ilari, A. (2023): Quality Assessment and Classification of Feedstock for Bioenergy Applications Considering ISO 17225 Standard on Solid Biofuels, Resources 2023, 12(6), 69, https://www.mdpi.com/2079-9276/12/6/69 (accessed on 01 March 2024).
3. ***: Associated Pallets Ltd (2024), https://associated-pallets.co.uk/blog/what-is-the-lifespan-of-a-pallet/) (accessed on 14 March 2024).
4. ***: European Pallet Association EPAL, https://www.epal-pallets.org/eu-en/load-carriers/epal-euro-pallet (accessed on 02 February 2024).
5. ***: European Parlament and the Council of the European Union (2010): Regulation (EU) 995/2010, https://eur-lex.europa.eu/legal- content/EN/TXT/?uri= celex%3A32010R0995 (accessed on 01 March 2024).
6. ***: European Parlament and the Council of the European Union (2023): Regulation (EU) 2023/1115, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1115 (accessed on 01 March 2024).
7. ***: Eurostat: https://ec.europa.eu/eurostat/comext/newxtweb/setupdimselection.do, (accessed on 18 January 2024).
8. ***: Global Compliance News (2024): https://www.globalcompliancenews.com/2023/12/20/european-union-deforestation-regulation-new-due-diligence-requirements-to-tackle-deforestation-and-forest-degradation/ (accessed on 18 March 2024).
9. ***: The Altenstadt Combined Heat and Power plant, https://www.heizkraftwerk-altenstadt.de/en/waste-wood-classes/, (accessed on 28 March 2024).
10. ***: The Commision of the European Communities (2000): Commission decision of 3 may 2000 replacing decision 94/3/ec establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/eec on waste and Council Decision 94/904/ec establishing a list of hazardous waste pursuant to Article 1(4) of council directive 91/689/eec on hazardous waste, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32000D0532 (accessed on 08 March 2024).
11. ***: The Freedonia Group (2020), https://www.prnewswire.com/news-releases/global-wood-pallet-demand-to-reach-5-8-billion-units-in-2024--301066267.html (accessed on 06 March 2024).
12. ***: ISO 445 (2013): Pallets for Materials Handling. Vocabulary. https://www.iso.org/standard/61915.html (accessed on 05 February 2024).
13. ***: ISO 15629 (2002): Pallets for materials handling. Quality of fasteners for assembly of new and repair of used, flat, wooden pallets, https://www.iso.org/standard/27924.html (accessed on 05 February 2024).
14. ***: ISO 18333 (2014): Pallets for materials handling. Quality of new wooden components for flat pallets, https://www.iso.org/standard/61430.html (accessed on 05 February 2024).
15. ***: ISO 18334 (2010): Pallets for materials handling. Quality of assembly of new wooden pallets, https://www.iso.org/standard/52147.html (accessed on 05 February 2024).
16. ***: ISO 18613 (2014): Pallets for materials handling. Repair of flat wooden pallets. https://www.iso.org/standard/62562.html (accessed on 05 February 2024).

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IMPROVING SUSTAINABILITY THROUGH NEW PRODUCTION PERSPECTIVES

TOWARDS SUSTAINABLE DEVELOPMENT IN THE WOODWORKING ENTERPRISES IN SLOVAKIA

Patrik Richnák, Peter Drábik, Eva Hanuláková, Róbert Rehák

Abstract: Today, the woodworking enterprises are undergoing a radical transformation, characterised by a growing recognition of the need for sustainability. Based on increased environmental awareness and changing societal expectations, woodworking enterprises are introducing modern processes, tools and technologies with sustainability principles. Their implementation in the business environment reduces waste, energy consumption and emissions, further reducing the environmental footprint of the woodworking industry. Sustainable business processes in the woodworking industry aim to reconcile economic growth, social justice and environmental responsibility, recognising the interconnectedness of these three pillars. This paper will aim to analyse the towards sustainable development in 62 woodworking enterprises in Slovakia, emphasising the strategic requirements, challenges and transformational pathways that are shaping this key transition.
Keywords: Sustainability, Sustainable Development, Sustainable Development Goals, Woodworking Industry

1. INTRODUCTION

The European Union's current requires to its member states in the areas of sustainability and a climate-neutral economy - such as Agenda 2030 or A Clean Planet for All - show how urgently it is becoming to determine what adjustments to make to the way that natural resources are used, both nonrenewable and renewable (Michal et al., 2021). Environmental problems and climate change are having a bigger impact on policy decisions and economic growth. In order to attain both ecological balance and long-term human prosperity, sustainable development has emerged as the most crucial and important component (Zhang et al., 2024). Sustainable development is a way of developing human society that reconciles economic and social progress with the full preservation of the environment for present and future generations. Preserving the environment for future generations in the least altered form is one of the fundamental objectives of sustainable development (Loučanová et al., 2023). The concept of sustainable development takes on particular importance in the era of the knowledge society and economy, as knowledge is the driving force behind the development of individuals and the economy as a whole. In this context, the concept of sustainable development in the business environment is often seen as synonymous with success and innovation behaviour and often has a pro-environmental character in relation to different stakeholder groups in the process of building systemic value (Grupa Azoty, 2021). Sustainable development centres on the integration of social, environmental, and economic advantages and fully incorporates all social, economic, resource, and environmental issues (Deng et al., 2019). Socially, environmentally, economically, and in terms of resource sustainability, sustainable development is described as the development that fulfils the needs of current generation without affecting or compromising future generation's ability to fulfil their own needs (Giddings et al., 2002). Achieving sustainable development can be approached from the following two perspectives: alleviating environmental problems and improving social equity. In terms of addressing environmental problems, increasing energy efficiency can partially mitigate the adverse impacts of environmental emissions on sustainable development, thereby promoting it (Dincer & Rosen, 1999). In terms of enhancing social equity, the use of blockchain technology is coming to the fore, providing convenience to various economic actors by enabling paperless, automated and publicly verifiable transactions in real time, thereby improving social equity (Günay et al., 2023) and promoting sustainable development.

In 2015, nations from around the world came together in Paris to try to create a framework with specific goals (Sustainable Development Goals/SDGs) and ensure that they are met by 2030 (United Nations, 2015). The Sustainable Development Goals are a set of 17 goals adopted by the United Nations in 2015, aimed at achieving sustainable development and addressing global challenges such as poverty, inequality, climate change, and environmental degradation (Qazi et al., 2023). The SDGs are designed to be universal and applicable to all countries, regardless of their level of development or economic status (Sachs et al., 2021). According to the 2030 Agenda for Sustainable Development, it is a responsibility of the international community to accomplish 17 goals by 2030, which are measured by 169 targets. Authors such as Yi & Thomas (2007) and Gavkalova et al. (2022) have pointed out that achieving the SDGs will require enterprises, the government, and society to come together and communicate effectively (Saura et al., 2022). Nonetheless, since the SDGs were first announced, NGOs, governments, and international organizations have mostly committed to attaining them by releasing yearly reports. Numerous big businesses and multinational enterprises have also demonstrated how important it is to participate in the SDGs (Fidlerová et al., 2022). Growing in significance is the industry's sustainable development, which takes into account social, economic, and environmental factors. This strategy aligns with the study of the wood-based industry's sustainable development. The wood processing business appears to be important from social and economic perspectives as well as from the position of ecologically friendly industries, according to Azizi et al. (2016). In light of the current environmental concerns, it's critical to preserve the socioeconomic activity balance for both current and future generations.

2. CHARACTERISTICS OF RESPONDENTS

In the present paper, 62 woodworking enterprises from the Slovakia were the subject of the empirical survey. Based on the European Commission Directive (2003/361/EC), which divides enterprises into three categories: small enterprises (10-49 employees), medium-sized enterprises (50-249 employees) and large enterprises (>= 250 persons), the enterprises were categorised on the basis of their size. 53.23 % of medium-sized woodworking enterprises, 33.87 % of large woodworking enterprises and 12.90 % of small woodworking enterprises participated in the questionnaire survey. The most represented legal form of business was the limited liability company (67.74 %). Enterprises operating as the joint stock company obtained a share of 27.42 %. State-owned enterprises also participated in the questionnaire survey with a share of 4.84 %. The geographical location of woodworking enterprises in the Slovakia was also considered in the selection of the research sample. From the data analysis we concluded that woodworking enterprises in the Slovakia were dominated in the Nitra Region. Their share was 25.81 %. Woodworking enterprises from the Žilina Region with a share of 19.35 % had the second highest share of participation. Furthermore, woodworking enterprises from the Banská Bystrica Region (17.74 %), the Prešov Region (12.90 %), the Trnava Region (8.07 %) were represented in the survey. The same share of participation (6.45 %) was obtained by a woodworking enterprises in the Bratislava and Košice Regions. The smallest participation of woodworking enterprises was recorded from the Trenčín Region (3.23 %).

3. RESULTS AND DISCUSSION

The basis for obtaining knowledge about sustainable development in woodworking enterprises in Slovakia was the implementation of the empirical survey. An electronic questionnaire was distributed to managers of enterprises in the woodworking industry in Slovakia. The questionnaire questions were designed in such a way that the current state of the research problem and further possibilities for the development of sustainable development in the woodworking industry in Slovakia could be identified.

Respondents were asked in the questionnaire how important sustainability development is nowadays as part of their business activities. The answers of the respondents revealed that 69.35 % of woodworking enterprises in Slovakia promote the opinion that sustainable development is important for their business activities. It is partially important for 27.42 % of the enterprises surveyed. Only 3.23 % of the respondents stated that sustainable development is not important for them.

Though the idea of sustainable development has been around for a while, climate change has given it more attention and a whole new meaning in recent years. Sustainable Development Goals are promoted by 72.58 % of woodworking enterprises in Slovakia. They are partially promoted by 22.58 % of respondents. The Sustainable Development Goals are not promoted by 4.84 % of the enterprises surveyed.

The enterprises surveyed were asked how long the enterprise has been involved in sustainable development in its activities. In the range of 1-5 years, the largest share of woodworking enterprises (37.09 %) is engaged in sustainable development. In the range of 5-10 years, 30.65 % of the respondents are engaged in sustainable development. Woodworking enterprises in Slovakia have been engaged in sustainable development for less than 1 year with a share of 22.58 %. More than 10 years 9.68 % of the enterprises surveyed have been engaged in sustainable development for more than 10 years.

Next, the questionnaire survey inquired whether woodworking enterprises have a sustainability strategy and report on sustainability practices. More than 2/5 of respondents (45.16 %) have a sustainability strategy. A partially formulated sustainability strategy is in place for 30.65 % of the enterprises surveyed. A sustainability strategy is being prepared by 20.97 % of woodworking enterprises in Slovakia. Only 3.22 % of the respondents do not have a sustainability strategy and at the same time do not report on sustainability practices.

The empirical survey reveals that 38.70 % of the respondents prefer the environmental pillar in sustainable development. The evaluated results show that with an identical share of 30.65 % woodworking enterprises in Slovakia prefer the economic pillar and also the social pillar in the framework of sustainable development.

Table 1 summarises the absolute and relative frequencies of responses from the questionnaire survey. The responses of the respondents indicated that 27.42 % of the surveyed enterprises understood sustainable development as monitoring emissions and waste production. More than 1/5 of the enterprises surveyed, understand sustainable development as the use of ISO 14001 certification. Purchased raw materials are reused and/or recycled by 19.35 % of the enterprises surveyed consider sustainable development. The procurement policy of environmentally friendly products is a sustainable development for 16.13 % of respondents. The surveyed enterprises least perceive sustainable development as reducing transport costs (12.91 %).

Table 1. Identifying sustainable development

Possibility	Absolute Frequency	Relative Frequency
Monitoring emissions and waste production	17	27.42 %
Use of ISO 14001 certification	15	24.19 %
Purchased raw materials can be reused and/or recycled	12	19.35 %
Procurement policy for environmentally friendly products	10	16.13 %
Reduction of transport costs	8	12.91 %

Table 2 identifies the tools in the framework of sustainable development of woodworking enterprises in Slovakia. According to the aggregated data, 25.81 % of the respondents prefer Total Quality Environmental Management, while 20.97 % of the survey participants prefer sustainable manufacturing as well as sustainable logistics. Almost eighteen percent (17.74 %) of the participants prefer sustainable packaging in sustainable development. The respondents with a share of 14.51 % prefer green public procurement among the tools.

Table 2. Sustainable development tools

Possibility	Absolute Frequency	Relative Frequency
Total Quality Environmental Management	16	25.81 %
Sustainable manufacturing	13	20.97 %
Sustainable logistics	13	20.97 %
Sustainable packaging	11	17.74 %
Green public procurement	9	14.51 %

An important part of the questionnaire survey was to identify what are the barriers to the implementation of sustainable development in woodworking enterprises in Slovakia. Table 3 identifies that respondents consider lack of state support to be the biggest barrier. At the same time, more than 1/4 of the respondents opined that they do not have enough financial resources to implement sustainable development. Administrative complexity is considered as one of the barriers by 22.58 % of the respondents. Lack of interest from the top management was the next rated barrier with 6.45 %. Lack of knowledge and information was the least barrier (3.23 %) for woodworking enterprises to implement sustainable development.

Table 3. Barriers to implementing sustainable development

Possibility	**Absolute Frequency**	**Relative Frequency**
Lack of state support	23	37.09 %
Lack of funding	19	30.65 %
Administrative complexity	14	22.58 %
Lack of interest from top management	4	6.45 %
Lack of knowledge and information	2	3.23 %

4. CONCLUSIONS

Towards sustainable development is an increasingly important factor in the business of all economic actors, and its role in the woodworking industry is even more pronounced. Through a questionnaire survey on sustainable development in woodworking enterprises in Slovakia, we identified that the majority of respondents believe that sustainable development is important for their business activities. Sustainable Development Goals are supported by almost 3/4 of woodworking enterprises in Slovakia. Almost half of the respondents have a sustainable development strategy and report on sustainable development practices. Of the pillars of sustainable development, the environmental pillar is most preferred by respondents. Of the tools used in the framework of sustainable development, the preferred one is Total Quality Environmental Management (TQEM). The biggest barrier to implementing sustainable development is the lack of financial resources. The towards sustainable development in the woodworking industry reflects a broader paradigm shift towards recognising the interconnectedness of economic progress, environmental care and social well-being.

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REFERENCES

1. Azizi, M., Mohebbi, N., De Felice, F. (2016). Evaluation of Sustainable Development of Wooden Furniture Industry Using Multi criteria Decision Making Method. *Agriculture and Agricultural Science Procedia*, 8, pp. 387–394. doi:https://doi.org/10.1016/j.aaspro.2016.02.034.
2. Deng, X., Huang, Z., Cheng, X. (2019). FinTech and Sustainable Development: Evidence from China based on P2P Data. *Sustainability*, 11(22), p. 6434. doi:https://doi.org/10.3390/su11226434.
3. Dincer, I., Rosen, M. A. (1999). Energy, environment and sustainable development. *Applied Energy*, 64(1), pp. 427–440. doi:https://doi.org/10.1016/S0306-2619(99)00111-7.
4. Fidlerová, H., Stareček, A., Vraňaková, N., Bulut, C., Keaney, M. (2022). Sustainable Entrepreneurship for Business Opportunity Recognition: Analysis of an Awareness Questionnaire among Organisations. *Energies*, 15(3), p. 849. https://doi.org/10.3390/en15030849.
5. Gavkalova, N., Akimova, L., Zilinska, A., Avedyan, L., Akimov, O., Kyrychenko, Y. (2022). Efficiency in the Context of Ensuring Sustainable Territorial Development. *Financial and credit*

activity problems of theory and practice, 4(45), pp. 234–243. doi:https://doi.org/10.55643/fcaptp.4.45.2022.3830.

6. Giddings, B., Hopwood, B., O'Brien, G. (2002). Environment, economy and society: fitting them together into sustainable development. *Sustainable Development*, 10(4), pp. 187–196. doi:https://doi.org/10.1002/sd.199.
7. Grupa Azoty. (2021). *Strategia Grupy Kapitałowej na Lata 2021–2030*. Available at: https://grupaazoty.com/upload/1/files/2021/strategia2021-2030/29.10.2021/2Grupa_azoty_strategia_2030_prezentacja_28_10_2021.pdf
8. Günay, S., Sraieb, M. M., Kaşkaloğlu, K., Yıldız, M. E. (2023). Cryptocurrencies and global sustainability: do blockchained sectors have distinctive effects? *Journal of Cleaner Production*, 425, pp. 138943–138943. doi:https://doi.org/10.1016/j.jclepro.2023.138943.
9. Loučanová, E., Nosáľová, M., Olšiaková, M., Štofková, Z., Dumiter, F. C., Nicoară, Ș. A., Boiță, M. (2023). Innovation as a Tool for Sustainable Development in Small and Medium Size Enterprises in Slovakia. *Sustainability*, 15(21), pp. 15393–15393. doi:https://doi.org/10.3390/su152115393.
10. Michal, J., Březina, D., Šafařík, D., Babuka, R. (2021). Sustainable Development Model of Performance of Woodworking Enterprises in the Czech Republic. *Forests*, 12(6), p. 672. doi:https://doi.org/10.3390/f12060672.
11. Qazi, A. (2023). Exploring Global Competitiveness Index 4.0 through the lens of country risk. *Technological Forecasting and Social Change*, 196, pp. 122856–122856. doi:https://doi.org/10.1016/j.techfore.2023.122856.
12. Sachs, J. D., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G. (2019). *Sustainable Development Report 2019.* Available at: https://www.sustainabledevelopment.report/reports/sustainable-development-report-2019/.
13. Saura, J.R., Ribeiro-Soriano, D., Palacios-Marqués, D. (2022). Assessing behavioral data science privacy issues in government artificial intelligence deployment. *Government Information Quarterly*, 39(4), p. 101679. doi:https://doi.org/10.1016/j.giq.2022.101679.
14. United Nations (2015). *Transforming Our World: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs*. Available at: https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981.
15. Yi, L., Thomas, H. R. (2007). A review of research on the environmental impact of e-business and ICT. *Environment International*, 33(6), pp. 841–849. doi:https://doi.org/10.1016/j.envint.2007.03.015.
16. Zhang, M., Song, G., Ma, N. (2024). A mechanism for upgrading the global value chain of China's wood industries based on sustainable green growth. *Journal of Cleaner Production*, pp. 141717–141717. doi:https://doi.org/10.1016/j.jclepro.2024.141717.

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EVALUATING THE POSSIBILITIES OF LCA ANALYSIS IN CAD SOFTWARE FOR WOOD PRODUCTS

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Jože Kropivšek, Teja Bizjak Govedič, Matej Jošt

Abstract: Wood is recognised by the European Union as a promising and sustainable raw material. However, as with other materials, emissions and impacts must be monitored throughout the life cycle of products in order to maintain the positive environmental characteristics. Often a full LCA is carried out to assess the environmental footprint of a product, but some CAD programmes have integrated sustainability assessment as one of the functions. They allow for a simple emissions assessment during the modelling phase. The benefits are mainly recognised for environmentally conscious manufacturing, but some software makes it possible to determine the entire life cycle of a product. Considering the environmental impact in the product modelling phase with CAD software is a simpler solution for more conscious production. The aim of this study is to evaluate whether software that is primarily intended for mechanical modelling can also evaluate wood products and in what extent. Ensuring that the data gaps relating to the life cycle emissions of wood-based materials and products are closed will make it easier for CAD developers to include the assessment of wood in their LCA-like tools. Furthermore, as wood-based materials are very diverse, the integration of AI into such tools will enable faster and more accurate assessments.
Keywords: CAD software, sustainability tools, wood product design, circular economy, digitalisation

1. INTRODUCTION

A circular bioeconomy has been recognised as one of the solutions to reduce global warming and greenhouse gas (GHG) emissions such as CO_2. The aim of the EU's transition to a circular economy is to reduce pressure on natural resources and create sustainable growth and jobs. This is also a prerequisite for achieving the EU's 2050 climate neutrality target and halting biodiversity loss (A new circular economy action plan, 2020). Strategic changes in the industry are needed to achieve this environmental milestone. In countries and regions with large forest areas, lignocellulosic biomass is considered a pathway to a climate-neutral industry (Juvančič et al., 2023). In addition to the resource-based changes in industry, digitalisation is also recognised by the EU. Digitalisation not only offers opportunities for the general development of society, but also enables a more sustainable manufacturing industry through the digital monitoring of emissions and resource consumption. Since the introduction of Industry 5.0, new priorities have emerged for the development of industry. One of these is the conservation of resources, climate change and social stability (RTD, 2022). The importance of digitalisation, digital twins and virtual prototyping in the context of more sustainable products and manufacturing is recognised in various documents, strategies and initiatives, e.g. in the New industrial strategy (EC, 2020), the Net Zero Industry Act (EC, 2023), the SME strategy for a sustainable and digital Europe (EC, 2023), and the 2030 Digital Compass: the European way for the Digital Decade (EC, 2021).

Life Cycle Assessment (LCA) is often used to assess the environmental impact of products throughout their life cycle – from raw material acquisition, manufacturing and use to waste treatment and disposal (Sala et al., 2021; Sinkko et al., 2023). However, as LCA is time-consuming and requires specialised knowledge, many leading CAD and CAE software companies have integrated LCA-like tools with supporting databases into their software to make environmental impact assessment in the manufacturing industry simpler, faster and more accessible. (Assad et al., 2021; Chen et al., 2017). Assessing the sustainability performance of digital twins at the early design stage with such tools can quickly minimise resource consumption and environmental impact as well as unnecessary production costs. However, different CAD software programmes have integrated different tools and offer inconsistent assessment options. Furthermore, most of these CAD programmes and their LCA-like plug-ins were not originally developed for the woodworking industry and for wood-based products. As the focus of industrial development is on the substitution of fossil-based materials with renewable ones, this study aims to analyse to what extent, if at all, an ecological assessment of wood products in CAD software is possible.

2. CAD-INTEGRATED SUSTAINABILITY ASSESSMENT TOOLS FOR THE WOOD-BASED SECTOR

Wood-based materials are considered a promising substitute for fossil materials, but many CAD programmes with integrated LCA or sustainability tools do not fully support the environmental assessment of wood as a material. This study therefore describes the extent to which the assessment of wood products is possible in selected CAD programmes. The programmes examined are: Solidworks, NX, Rhinoceros, Fusion 360, Inventor and Catia.

2.1 Solidworks

The Solidworks software has an integrated sustainability assessment based on the LCA method. Depending on the licence type, Solidworks SustainabilityXpress or Solidworks Sustainability (premium licence) is available. The main difference between the two tools is the ability of Solidworks Sustainability to assess assemblies, while SustainabilityXpress only allows the assessment of parts. However, both tools are supported by external LCA data – the GaBi environmental database. Sustainability and SustainabilityXpress allow LCA-like assessment in real time. In Solidworks Sustainability, wood-based materials are classified as “Wood" and “Sustainability Extras: Building Materials”. Data is available for balsa, beech, cedar, mahogany, maple, oak, pine and teak as well as for particleboard, KLH, OSB, chipboard (uncoated and coated) and wood flooring laminate. In addition, the "Find similar" search engine can be used to search for a range of other materials. With the sustainability tool, we can define the material, which is automatically defined as mass, the region where it is produced, the lifetime of the product, additional processes (electricity consumption, natural gas consumption, scrap rate, coatings – no/water-based paint/solvent-based paint/powder coating), the region where it is used, the transport, the end-of-life scenario (percentage of recycling, incineration and landfill) and the duration of use. The impact categories to be monitored (carbon footprint, energy consumption, air acidification, water eutrophication) are presented as pie charts (Figure 1) showing the proportions of the impacts from the scenarios for the input materials, production, utilisation phase, transport and end of life.

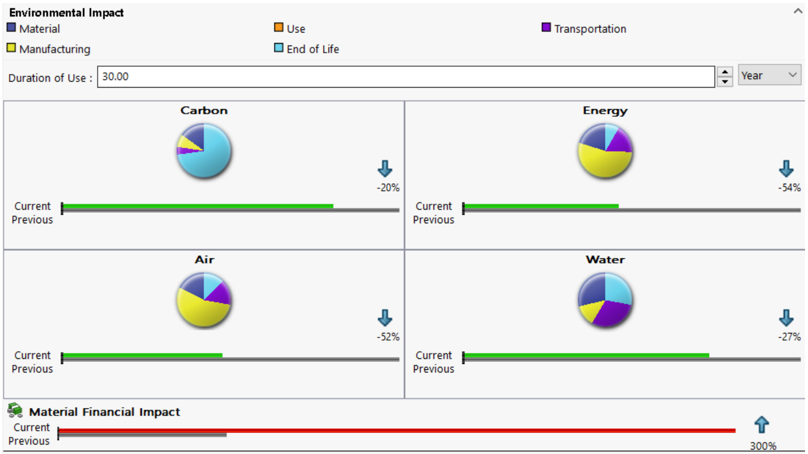

Figure 1. Graphical visualisation of LCA results in Solidworks Sustainability

2.2 NX

Nx Sustainability impact assessment is an integrated function of the NX software. It enables a quick environmental impact assessment during the design phase in real time. Based on the assigned material, parts and assemblies can be ecologically assessed in various categories: Climate change, fresh water consumption, human toxicity, energy consumption (renewable and non-renewable). NX Sustainability enables visual representations and also provides an overall sustainability rating that takes into account the proportion of recycled content. The materials included in the NX library do not include wood species or wood composites. However, NX Sustainability allows the import of external databases containing wood-based materials.

2.3 Rhinoceros

Bombyx is a third-party plugin for the Grasshopper extension in Rhinoceros that was developed by ETH Zurich and is therefore supported by an external database of the same company. The database is extensive and supports a variety of wood materials. As the plugin was originally developed for architecture, the most important assessment category is global warming potential. In conjunction with another plugin – Hive - the energy demand can also be assessed. Based on the 3D model of the layered structure, the data can be parametrically linked via the plugin to create a time-efficient life cycle assessment. Structural changes and the replacement of materials can be monitored in real time. However, the creation of a calculation model (Figure 3) in Grasshopper is associated with a greater learning effort than environmental assessments with plug-ins in other programmes.

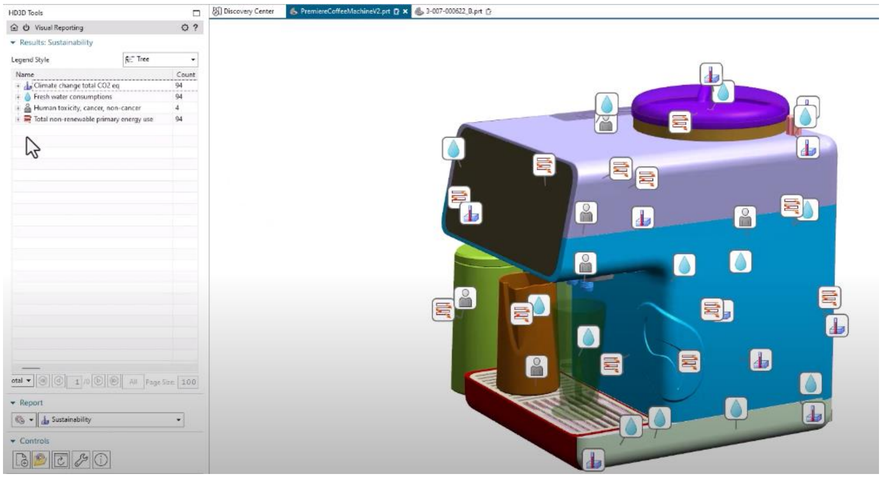

Figure 2. Visualisation of the environmental impact for each component of the assembly in NX Sustainability impact assessment

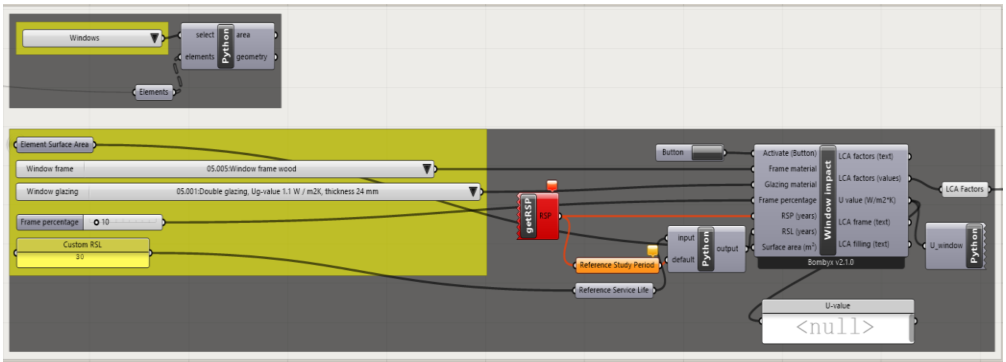

Figure 3. Pathway of life cycle assessment calculation in the Rhinoceros Bombyx

In recent years many add-ons for Rhinoceros and Grasshopper have been developed, but they all function on similar basis in path modelling in Grasshopper. They differentiate mostly based on the external supporting database. Some of such plugins are: One Click LCA, Cardinal LCA, Brimstone, Caala for Rhino, Epic Grasshopper and Goeko.

2.4 Fusion 360

Autodesk Fusion 360 allows us to install various add-ons. A very commonly used environmental add-on is Manufacturing Sustainability Insights (MSI), which provides sequestered carbon data directly from the 3D model. Fusion has an integrated material library that allows us to predefine the materials of parts and assemblies. The Fusion Library includes the following wood-based materials: selected hardwood species (ash, birch, cherry, maple, jarrah, lauan, mahogany, white oak, red oak, poplar, spruce, teak, walnut, redwood), selected softwood species (douglas fir, scots pine, radiata pine, scots pine, southern pine), selected wood-based materials (LVL, MDF, particleboard, plywood - sheathing and surface treatment), shingles – siding, softwood - lumber and surface treatment, construction timber (oak), construction timber, wood flooring. MSI then recognises the selected materials and suggests the most similar material from the MSI database. The information and calculations are supported by the Gravity Climate platform for carbon accounting. The add-in allows us to select the manufacturing type and additionally compare different manufacturing types for a selected part. The add-in also allows us to specify the manufacturing region and country. The MSI material data includes some polymer materials and selected metals. However, there are no wood types or wood composites, so the plugin is not suitable for evaluating wood products. The results of the assessment are calculated in real time as CO_2 emissions (Figure 4).

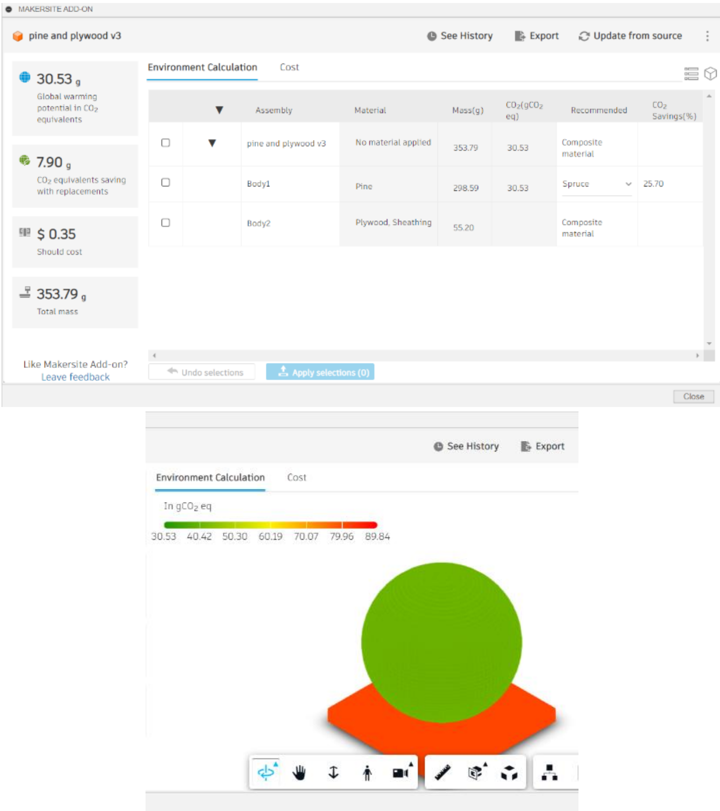

Figure 4. Results of the global warming potential assessment with Makersite in Fusion 360

Another Fusion plugin that also works on the basis of predefined physical materials is Makersite. It is an AI-based, real-time global warming potential assessment tool. The 3D model is exported as a bill of materials (BOM). The mass is automatically assigned and substitute materials are recommended along with the estimated CO_2 savings in percentages. However, the database is limited in wood species and composites, plywood is not included for example. Makersite also allows us to graphically display the CO_2 emissions of assemblies in a heat map (Figure 5).

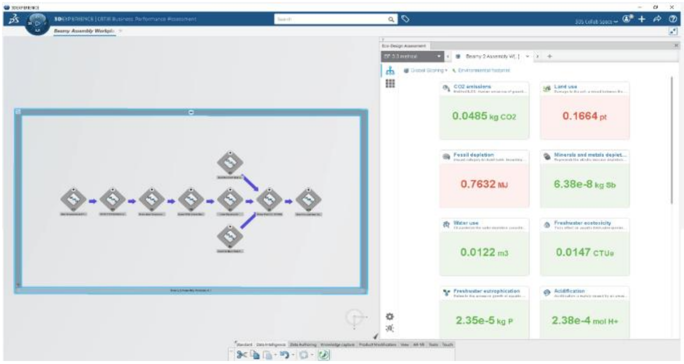

Figure 5. Eco-Designer Engineer tool in 3DEXPERIENCE platform from Dassault Systems

New solutions for the life cycle assessment of 3D models in Fusion 360 are also being developed. The collaboration between Autodesk, PRé Sustainability and ProtoTech Solutions is currently in the test phase. It will enable the life cycle assessment of 3D models using the SimaPRO LCA tool and the Ecoinvent database. The assessment will be available via the Autodesk Platform Services – API.

2.5 Inventor

Eco Materials Adviser used to be a very frequently used third-party solution for the environmental assessment of products. However, the add-on was not updated beyond the Autodesk Inventor 2020 version. Since then, Inventor does not support direct sustainability assessment of 3D models.

2.6 Catia

The CATIA software is part of Dassault Systems and thus part of the 3DEXPERIENCE PLATFORM, which enables various real-time monitoring of a product. The impact on the environment is often assessed using the Eco-Design Engineer tool, which enables a complete LCA analysis. Based on the imported 3D model, we assign the material, the manufacturing region, the type of processing, the type of energy used and the end-of-life scenario to each component. The platform is connected to the external database – Ecoinvent - and therefore offers a wide range of data that can be selected for all input categories. A hotspot analysis can be performed for the production of a product as well as a comparative analysis after some changes have been made to improve the environmental impact of the selected product. The calculations are displayed for the following metrics: CO_2 emissions, land use, fossil depletion, water use, minerals and metals depletion, freshwater ecotoxicity, freshwater eutrophication, acidification, marine eutrophication, terrestrial eutrophication, photochemical ozone formation, respiratory effects, ionising radiation, carcinogenic effects, non-carcinogenic effects. For each of these parameters, the specific limit values that the product must not exceed can be defined. Both the structural and the phased distribution of CO_2 can be visualised. The structural distribution shows the CO_2 emissions for each part or component.

3. CONCLUSION

The wood processing sector is undoubtedly a promising industry for the future. Nevertheless, the impact of products and related processes must be closely monitored to avoid unexpected negative environmental impacts. CAD-integrated sustainability tools have proven to be a solution for monitoring environmental impact in the early design phase. However, as they are based on some kind of material library or external databases, the possibilities for the assessment of wood-based materials are limited, as most CAD programmes were not developed for the wood-based materials industry. Some tools are more suitable for the wood industry than others, but also require more time and expertise to perform environmental assessments. The aim of future work is therefore to fill the missing data gaps in such tools. CAD-integrated sustainability tools are under development and will even be connected to AI to improve the selection of the right materials and processes from the database and make the assessment easier and faster.

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REFERENCES

1. Assad, F., Konstantinov, S., Rushforth, E. J., Vera, D. A., & Harrison, R. (2021). Virtual engineering in the support of sustainable assembly systems. *Procedia CIRP*, *97*, 367-372. https://doi.org/https://doi.org/10.1016/j.procir.2020.05.252
2. Basic, S., Hollberg, A., Galimshina, A., Habert, A. (2019): A design integrated tool for real-time life assessment – Bombyx project. Sustainable built environment conference 2019 (SBE19 Graz), 323. doi:10.1088/1755-1315/323/1/012112
3. Chen, Z., Tao, J., & Yu, S. (2017). A Feature-based CAD-LCA Software Integration Approach for Eco-design. *Procedia CIRP*, *61*, 721-726. https://doi.org/https://doi.org/10.1016/j.procir.2016.11.228
4. GRANTA Material Intelligence: Eco materials advisor in Autodesk Inventor. URL: https://www.grantadesign.com/download/pdf/EcoMaterialsAdviser.pdf (26.3.2024)

5. Juvančič, L., Osojnik Črnivec, I. G., Berne, S., Oven, P., & Mihelič, R. (2023). *Povzetek strokovnih izhodišč za strategijo razvoja biogospodarstva v Sloveniji*. https://www.daes.si/storage/post-content/qb3NGrBnNyykTFfCy8gmJSeGR8k9jhYXYnIaEklQ.pdf
6. Sala, S., Amadei, A. M., Beylot, A., & Ardente, F. (2021). The evolution of life cycle assessment in European policies over three decades. *The International Journal of Life Cycle Assessment*, *26*(12), 2295-2314. https://doi.org/10.1007/s11367-021-01893-2
7. Sinkko, T., Sanyé-Mengual, E., Corrado, S., Giuntoli, J., & Sala, S. (2023). The EU Bioeconomy Footprint: Using life cycle assessment to monitor environmental impacts of the EU Bioeconomy. *Sustainable Production and Consumption*, *37*, 169-179. https://doi.org/https://doi.org/10.1016/j.spc.2023.02.015
8. *** A new circular economy action plan, European Comission (2020). URL: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en (Accessed on 27.3.2024)
9. *** AUTODESK (2023): Carbon is the culprit: Uncovering manufacturing sustainability insights. URL: https://www.autodesk.com/autodesk-university/class/Carbon-Is-the-Culprit-Uncovering-Manufacturing-Sustainability-Insights-2023 (Accessed on 27.3.2024)
10. *** AUTODESK (2023): Get real-time sustainability insights with the marketsite add-on for Fusion 360. URL: https://www.autodesk.com/products/fusion-360/blog/makersite-add-on-for-fusion-360-sustainability/ (Accessed on 27.3.2024)
11. *** AUTODESK App Store (2023): Manufacturing sustainability insights. URL: https://apps.autodesk.com/FUSION/cs/Detail/Index?id=5902568957837856470&appLang=en&os=Win64 (Accessed on 27.3.2024)
12. *** AUTODESK App Store: Eco materials adviser. URL: https://apps.autodesk.com/INVNTOR/en/Detail/Index?id=8391666263963684768&appLang=en&os=Win64 (Accessed on 26.3.2024)
13. *** AUTODESK Platform Services. URL: https://aps.autodesk.com/customer-stories/pre-sustainability (Accessed on 26.3.2024)
14. *** AUTODESK: Autodesk Fusion 360 powered by SimaPro: Sustainability at the beginning. URL: https://www.autodesk.com/autodesk-university/class/Autodesk-Fusion-360-Powered-SimaPro-Sustainability-beginning-2022#downloads (Accessed on 26.3.2024)
15. *** EC (2020): Making Europe's business future-ready: A new industrial strategy for a globally competitive, green and digital Europe. URL: https://ec.europa.eu/commission/presscorner/detail/en/ip_20_416 (Accesed on 20.2.2024)
16. *** EC (2021): 2030 Digital compass: the European way for the digital decade. URL: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021DC0118 (Accesed on 20.3.2024)
17. *** EC., CNECT. (2023): *2030 Digital Decade: report on the state of the Digital Decade 2023*. Publications Office of the European Union.
18. *** food4Rhino, Apps for Rhino and Grasshopper. URL: https://www.food4rhino.com/en/app/bombyx (Accessed on 27.3.2024)
19. *** RTD (2022): Industry 5.0: A transformative vision for Europe – Governing systematic transformation towards a sustainable industry. URL: https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/industry-50-transformative-vision-europe_en#files (Accessed on 26.3.2024)
20. *** Markersite: Insights. URL: https://makersite.io/insights/ (Accessed on 27.3.2024)
21. *** SEIEMNS (2023): What's new in NX sustainability impact analysis tool. URL: https://blogs.sw.siemens.com/nx-design/nx-sustainability-impact-analysis/ (Accessed on 27.3.2024)

22. *** SIEMENS (2023): Introducing NX Sustainability impact analysis. URL: https://blogs.sw.siemens.com/nx-design/announcing-nx-cad-sustainability-impact-analysis-for-product-design/ (Accessed on 27.3.2024)
23. *** SolidWorks Engineering design and technology series: SolidWorks Sustainability – An introduction to sustainable design. URL: https://www.solidworks.com/sw/docs/sustainability_wb_brake_assem_2011_eng.pdf
24. *** SolidWorks sustainability. URL: https://www.thesolidexperts.com/products/solidworks/simulation-analysis-design-validation/solidworks-sustainability (Accessed on 23.3.2024)
25. *** TECHNICA: What is CATIA? URL: https://www.technia.com/blog/what-is-catia/ (Accessed on 27.3.2024)
26. *** 3DEXPERIENCE: Eco-Desgn Engineer. URL: https://my.3dexperience.3ds.com/welcome/compass-world/rootroles/eco-design-engineer (Accessed on 26.3.2024)

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SCIENTIA EST LUX

SCALING FURNITURE MANUFACTURING MICRO COMPANIES INTO SMEs

Ivaylo Iliev

Abstract: The furniture manufacturing sector predominantly comprises MSMEs that started as a hobby or a passion project. Many of those micro companies never scale up or they do in a long period of time. In this study, a strategy to successfully scale a company through the use of financial instruments, improving internal processes, and human resources will be showcased.
Keywords: Micro companies, SMEs, Furniture Manufacturing, Scaling Strategy, Sustainable Management

1. THE CURRENT STATE OF FURNITURE MANUFACTURING MICRO COMPANIES

In the rapidly evolving market, furniture manufacturing micro companies face the daunting challenge of scaling up to small and medium-sized enterprises (SMEs). The journey from a micro to an SME status is fraught with challenges but offers significant rewards, including increased market reach, enhanced production capabilities, and greater financial stability.

Manufacturing of furniture has a significantly higher percentage of employment in micro and small enterprises compared to the average manufacturing sector (please see Graph 1). This suggests a greater number of smaller-scale operations within the furniture manufacturing industry. The chart showcases the unique structure of the furniture manufacturing industry in comparison to the broader manufacturing sector, emphasizing the importance of small and micro enterprises in providing employment and presumably in maintaining the diversity and vibrancy of the furniture market.

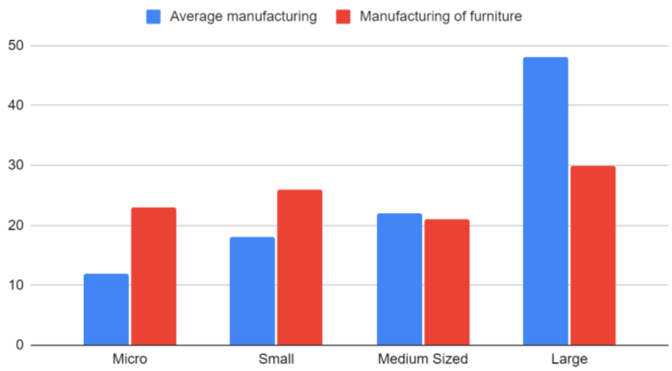

Figure 1: Enterprise size class chart for EU companies, 2021, data from Eurostat

2. CHALLENGES FACING MICRO COMPANIES

2.1. Competition and Market Pressures

Micro companies face intense competition from larger manufacturers and imported goods, often struggling to compete on price due to higher production costs. The globalization of the furniture market has intensified these pressures, with many micro-companies finding it challenging to expand their market reach beyond local or regional boundaries.

The author has conducted a survey among the people walking out from one of the bigger specialized stores for furniture mechanisms in Sofia, Bulgaria. The questions were directed at what were the considered competitive advantages for micro companies. The survey covered 50 people, which reported working or owning a micro-enterprise for furniture manufacturing. The author is going to use it as a representation of the struggles that a micro company in manufacturing is facing within the European Union.

The respondents were asked if the following were bringing competitive advantage for their business

Table 1: Competitive advantages of the micro companies

Product	Percentage %	People responding they feel that their business has a competitive advantage
Price of product/services	48%	24
Product quality	96%	48
Product customization	98%	49
Customer experience		
Excellent customer experience	98%	49
Personalized attention to each client	96%	48
Building lasting customer relationships	86%	43
Workforce		
Employee effectiveness	74%	37
Experience in furniture making	70%	35
Skilled workforce	84%	42
Focus on learning and continuous development	98%	49

Employee loyalty	72%	36
Company		
Openness to change	94%	47
Focus on development	86%	43
Political and legal restrictions	94%	47
Use of modern management tactics	24%	12
Tools & Machinery		
Own a variety of professional equipment	34%	17
Access to the possibility to finance (through loan) the purchase of large machines	14%	7

The survey results review a diverse range of competitive advantages across different aspects of the business, showcasing a varying degree of strengths and weaknesses. In the product category, there's a notable split in perception; while a large majority of respondents see product quality and customization as key competitive advantages they deliver upon, with 96% and 98% respectively, less than half consider the price of products and services to be an advantage their business relies on. This indicates that businesses may be competing more on the uniqueness and quality of their offerings rather than on cost.

Customer experience is another area where respondents overwhelmingly feel they have an edge, with excellent customer service and personalized attention each scoring high, at 98% and 96%. This high valuation suggests that businesses prioritize establishing a strong rapport with customers, which is seen as a crucial element for their success. The ability to build lasting relationships with customers is also highly regarded, though it is slightly less pronounced at 86%.

Regarding the workforce, a robust 98% of respondents identify a focus on learning and continuous development as a significant advantage, indicating a commitment to fostering a culture of improvement and skill advancement within their teams. A skilled workforce is considered an advantage that a strong majority has, but the effectiveness of employees and their loyalty, are not strong competitive advantages owned by the micro-enterprises in Bulgaria manufacturing furniture.

In the company category, openness to change and adeptness at navigating political and legal restrictions are considered major advantages by 94% of respondents, underscoring the importance of adaptability and regulatory compliance in the business landscape. However, the use of modern management tactics is not implemented or used by the respondents in the survey, suggesting a potential area for development or a preference for traditional management styles.

Finally, when it comes to tools and machinery, a minority of respondents own a variety of professional equipment and thus do not have a competitive advantage over larger enterprises. Even fewer have access to financing for large machine purchases. This indicates that this is one of the struggles that micro companies are facing in Bulgaria - getting funding to purchase large machinery and thus an opportunity to grow the business.

Collectively, these insights reflect that for micro-enterprises within furniture manufacturing, the key to their performance is excellence and customization in product offerings, coupled with high-quality customer service. At the same time, micro-enterprises have less access to large machinery equipment (they need to pay larger enterprises for a service in order to do certain tasks) and thus are losing on price competitiveness - simply because of the larger costs they make to create the product.

2.2. Regulatory and Environmental Challenges

Micro furniture manufacturers are facing significant challenges with regard to their compliance with the European Union environmental regulations. The last were designed to minimize the environmental impact of manufacturing processes and ensure the sustainable use of resources as well as safeguard customer health and safety.

The challenges that micro furniture manufacturers are facing are related to costs - compliance usually requires higher investments to upgrade facilities or use equipment that meets environmental standards. Micro companies usually don't have a legal team or the ability to pay for consultancy fees.

Compliance with European Union regulations, including environmental standards, safety norms, and labor laws, presents another significant hurdle. While these regulations aim to ensure sustainability and consumer protection, the associated compliance costs can be disproportionately high for micro companies.

In addition, adapting to a green production model can require significant changes to established manufacturing processes. This might involve reducing energy consumption, minimizing waste, or switching to less harmful chemicals and finishes. Such changes can necessitate a redesign of products or even the abandonment of traditional techniques that are integral to the identity of the micromanufacturer.

3. THE ROAD TO GROWTH

For micro furniture manufacturers to transition into small and medium-sized enterprises (SMEs), they must navigate a series of growth challenges while leveraging their unique strengths. One key strategy is differentiation; by focusing on the high quality and customization that already set them apart, these micro-businesses can carve out niche markets where they can command higher prices and customer loyalty. Building on this, they can invest in marketing and branding to elevate their visibility and value proposition in a crowded marketplace. Enhancing their online presence and e-commerce capabilities is also crucial, as digital channels can significantly expand their market reach beyond local boundaries.

Financing growth is another critical factor. Access to capital through loans, grants, or investors can enable investments in scaling up production capacity, modernizing equipment, and hiring additional skilled staff. Streamlining operations for efficiency, perhaps through adopting lean manufacturing principles, can help in managing costs and improving output as demand grows. With demand growing, they would be able to apply for larger loans in order to purchase bigger machinery and mre professional equipment that will allow them to grow to small and medium enterprises.

Additionally, aligning with environmental regulations not only ensures compliance but can also open doors to new market segments that value sustainability. Partnerships with larger distributors or entering into B2B contracts can provide steady revenue streams and further drive the transition from micro to SME status. By systematically addressing these areas, a micro furniture manufacturer can set the stage for sustainable growth and evolution into a small or medium-sized enterprise.

Another important factor for the growth of micro furniture manufacturers to SMEs is marketing. Effective marketing acts as the engine of growth, helping to build brand awareness, communicate the value proposition, and attract a larger customer base. Through different marketing channels, small-scale producers can showcase their unique designs, sustainable practices, and higher quality. Moreover, it allows manufacturers to engage directly with customers, gather feedback, and foster a community around their brand. As micro manufacturers scale into SMEs, marketing becomes increasingly critical to enter new markets, whether that’s geographically or through diversifying.

In conclusion, despite the myriad of challenges facing micro furniture manufacturers in the European market, the potential for growth into SMEs remains a tangible and achievable goal. By leveraging their strengths in producing high-quality, customizable products and by embracing the power of effective marketing to tell their unique stories, micro-enterprises can connect with a broader customer base and carve out their niche. Access to various forms of financing, a willingness to embrace sustainable practices, and the strategic use of digital tools can all act as catalysts for growth and help them become symbols of the entrepreneurial spirit that drives the European economy.

REFERENCES

1. Borowiecki, R.; Siuta-Tokarska, B.; Janas, M.; Kruk, S.; Krzemiński, P.; Thier, A.; Żmija, K (2022): *The Competitive Position of Small Business Furniture Industry Enterprises in Poland.* In: Context of Sustainable Management: Relationships, Interdependencies, and Effects of Activities. Sustainability 14, 9368.
   URL: https://doi.org/10.3390/su14159368
2. Ekberg, S., Hedell, J., (2011) *Perceived Challenges of Growth in Micro Enterprises*, Master Thesis in Jönköping International Business School, Jönköping University Sweden, May 2011
3. R.B. Avery, R.W. Bostic, K.A. Samolyk, (1998): *The role of personal wealth in small business finance*. In Journal of Banking & Finance, 22 (6) , pp. 1019-1061
4. T. Beck, A. (2006) *Demirguc-Kunt Small and medium-size enterprises: Access to finance as a growth constraint.* In: Journal of Banking & Finance, 30 (11), pp. 2931-2943
5. Yadollahi Farsi, J., Toghraee, M.T. (2014): Identification the main challenges of small and medium sized enterprises in exploiting of innovative opportunities *(Case study: Iran SMEs)*. In: J Glob Entrepr Res 4, 4
6. Jolovski, J., (2022): Modern trends in the budget public finance management, Sofia, VUZF
7. European Commission (2005): The new SME definition. User guide and model declaration.
   URL: https://www.eusmecentre.org.cn/wp-content/uploads/2022/12/SME-Definition.pdf

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MEASURING AND INCREASING THE OVERALL EQUIPMENT EFFICIENCY IN FURNITURE MANUFACTURING TOWARDS AGILE PROCESSES

Andrea Janáková Sujová, Ľubica Simanová

Abstract: Manufacturing companies are constantly looking for opportunities to improve process performance to maximize customer satisfaction and improve their financial performance. Current trends in process management related to the development of lean concepts and process agility bring to the fore the importance of monitoring the overall efficiency of production facilities. The aim of this paper is to show the determination of the level of the Overall Equipment Effectiveness (OEE) indicator in a selected production facility in furniture manufacturing (veneer gluing line), as well as the analysis of the causes of problems in the veneer bonding process and their impacts on the OEE. Source data was obtained by diagnosing and measuring organizational causes, disorders, and deficiencies in material quality. The continuous monitoring of downtime and its causes through the tracking of OEE levels allows to reveal opportunities to improve the performance of production processes and contributes to their agility.
Keywords: Overall Equipment Effectiveness (OEE), furniture manufacturing, performance, process agility

1. INTRODUCTION

Process agility refers to the ability to adapt to rapid changes, innovations, and market demands. In the context of manufacturing, this means that processes should be flexible to respond quickly to changes in demand, technology, or other factors. Process agility enables faster introduction of new products, optimization of production, increased performance, and better competitiveness. Agility is a widely debated concept and is often thought of as general change. The orientation of companies to agility is one of the keys to achieving commercial success. A widely held view emphasizes that agility is like a Swiss army knife because it represents a solution to almost any problem that companies face (Jesse, 2019).

Measuring process performance through OEE (Overall Equipment Effectiveness) as a quantitative indicator of the efficiency of production equipment expresses the percentage of production time that was actually used productively. OEE is considered a standard indicator in lean manufacturing systems and also serves as a benchmarking indicator. The intention of manufacturing companies at present is to increase productivity, quality, efficiency, and performance of production processes. When addressing competitiveness challenges, companies are forced to look for ways to improve the quality of their products, reduce costs and meet ever-changing customer requirements. The recent competitive trends and ever-increasing business pressures have been putting maintenance function under the spotlight as never before (Garg and Deshmukh, 2006). The changes in the current business environment are characterized by intense competition on the supply side and heightened volatility in customer requirements on the demand side. These changes have left their unmistakable marks on the different facets of the manufacturing organizations (Gomes et al., 2006). One of the successful solutions to these problems is the adoption of innovative techniques such as Total Productive Maintenance (TPM). It establishes a system of productive maintenance, covering the entire life cycle of equipment, covers all department, involves participation of all employees from top to bottom and promotes small group autonomous activities (Kumar et al., 2012). In manufacturing industries around the world, the Overall Equipment Effectiveness (OEE) indicator is used to monitor performance. Muchiri et al. (2011) state that most research on OEE concerns maintenance. Andersson and Bellgran (2015) complement other areas such as increasing productivity. The OEE is one of the innovative approaches to maintenance that eliminates breakdowns and promotes autonomous maintenance by operators through day to-day activities involving total workforce (Singh et al., 2013). OEE was originated from the Total Productive Maintenance practices, is define as a result can be expressed as the ration of the actual output of the equipment divided by the maximum output of the equipment under the best performance condition (Almeanazel, 2010). Zammori et al. (2011) considered OEE as a stochastic random variable, and of which the probability density function is generated through the aggregation of the probability density function of the underlying causes of waste. The authors Hedman et al. (2016), and Binti et al. (2016) emphasize that validity and usefulness of OEE estimate are highly dependent on the data collection which needs both availability and accuracy of data especially the accuracy which determines the OEE values.

Table 1. Maintenance rating based on the OEE.

OEE	CLASSIFICATION	MPACT ON COSTS AND COMPETITIVENESS
< 65%	Unacceptable	Economic losses. Low competitiveness
≥ 65% < 75%	Regular	Economic losses. Acceptable only if the quarterly trends are improving
≥ 75% < 85%	Acceptable	Slight economic losses. Slightly low competitiveness, it is necessary to improve
≥ 85% < 95%	Good	Good competitiveness
≥ 95%	Excellent	Excellent competitiveness

Source: Cercósa et al.2019

2. METHODOLOGY

Overall Equipment Effectiveness (OEE) represents the actual capacity to produce without defects, the process performance, and the equipment availability. It requires daily information of the process. Is considered the main indicator to measure the success of the implementation of the TPM methodology (Jeong, Phillips, 2001). It is calculated as the product of equipment availability, the efficiency of the process performance and the rate of quality products [Dal et al. 2000, Ljngberg, 1988). The formulation is the following (1):

$$OEE = A_{eff} x P_{eff} x Q_{eff} \qquad (1)$$

When:

A_{eff} *– The availability efficiency*
P_{eff} *– The Performance efficiency*
Q_{eff} *– The Quality efficiency*

Based on almost 50 years of experience, the American company Lean production states that the value of OEE in discrete production is in the values given in Table 2.

Table 2. OEE values according to the American company Lean production

OEE	CLASSIFICATION	IMPACT ON IMPROVEMENT
45 %	Low level	Not an unusual condition, a large area for rapid improvements through simple measures
60 %	Typical level	Typical level. Significant area for improvement.
85 %	World Class	World class level. A long-term goal for many companies.
100 %	Perfect level	Ideal production without downtime, with optimal speed and in perfect quality.

Source: https://4industry.consulting

3. RESULT AND DISCUSSION

Basic data on downtimes and their causes on the most faulty equipment - veneer gluing line were obtained during 45 weeks of production of furniture parts and are shown in percentages in figures 1 and 2.

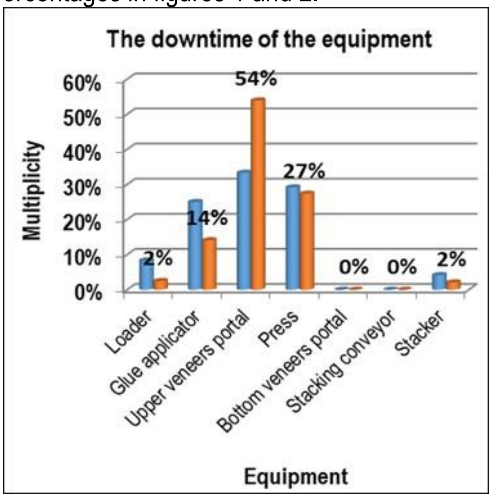

Figure 1. The downtime of the equipment

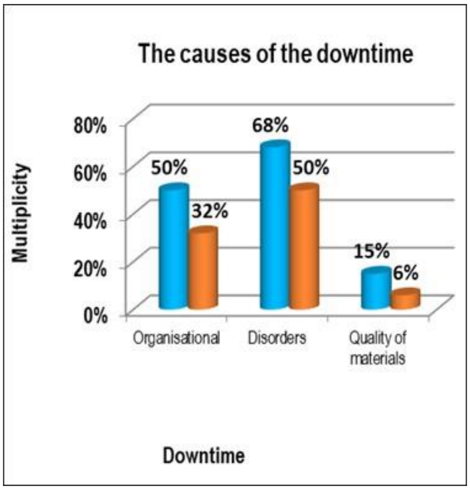

Figure 2. The causes of the downtime

Figure 1 shows the percentage of downtime on individual types of equipment needed in the production of furniture parts. The highest share of 54% of downtime from the total work time was found at the upper veneer's portal device, on which the operation of placing the veneer on the upper side of the part covered with glue is carried out. The organizational downtime was caused mainly by the replacement of suction cups, problems with the start-up of the equipment, slowing down of the veneer deposition speed and changes in the synchronization of the upper veneer's portal with the subsequent equipment, which was the press. After the introduction of corrective measures, there was a drop to the level of 32%. The resulting downtimes were caused by equipment failures at the level of 68%, after the introduction of corrective measures they decreased to 50%. We can conclude that the quality of the material had the lowest influence on the OEE indicator of equipment downtime, and the value dropped to 6% from 15% of detected material discrepancies.

The development of the individual OEE indicator and its components such as equipment availability, equipment performance and quality level expressed as a percentage over a period of 45 weeks of measurement and calculations is shown in Table 3.

Table 3. Values of availability, performance, quality and OEE indicator

Week	Availability rate %	Performance rate %	Quality rate %	OEE %
1. - 5.	92.63%	95.13%	89.17%	78.58%
6. - 10.	93.27%	91.26%	86.32%	73.47%
11. - 15.	93.12%	94.18%	82.48%	72.34%
16. - 20.	93.25%	93.17%	83.75%	72.76%
21. - 25.	92.98%	92.01%	82.51%	70.59%
26. - 30.	**95.72%**	**97.48%**	**93.19%**	**86.95%**
31. - 35.	**96.12%**	**96.59%**	**95.48%**	**88.65%**
36. - 40.	**95.17%**	**97.89%**	**95.53%**	**89.00%**
41. - 45.	**96.23%**	**94.28%**	**98.36%**	**89.24%**

Table 3 shows the time development of the OEE indicator. With the gradual introduction of corrective measures, the value of the OEE indicator rose to the level of 89.24%, while the average value of the OEE indicator showed a value of 88.46%, which is an increase of 73.55 % compared to the results of measurements and calculations in weeks 1-25.

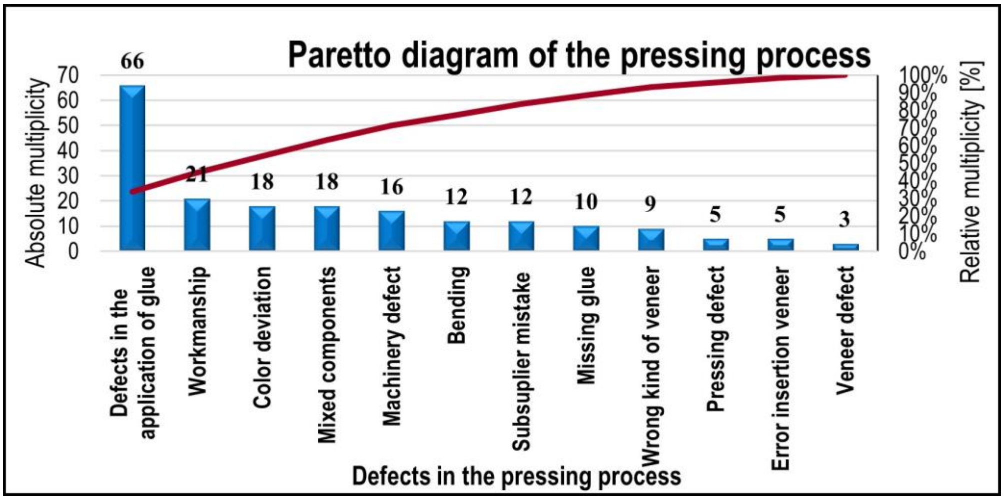

Figure 3. Pareto diagram of the pressing process

By detecting the occurrence of non-conformities through the Pareto diagram, key non-conformities affecting quality and subsequently the OEE indicator were identified. Baseline data were obtained by measuring disagreements over 45 weeks and their identification is shown in Figure 3.

The Pareto diagram of the pressing process shows that the performance of the pressing process was most affected by discrepancies caused by application of glue and workmanship.

4. CONCLUSION

The total average value of the OEE indicator during the measurements was 80.18%. In weeks 1-25, the average value of OEE reached the level of 73.55%. By comparing it with the evaluation classification according to Cercós et al. (2019) we can state that the veneer gluing line equipment was included in the classification group in the range ≥ 75% < 85% with an acceptable result, with moderate economic losses, low competitiveness and it was necessary to improve its performance. By comparing the results of the measurements with the OEE values according to the American company Lean production, we can place the device in the group of typical level with significant area for improvement. By identifying opportunities for improvement and after implementing corrective measures to improve the operation of the equipment, organizational measures, and measures to reduce the number of non-conformances, the average value of OEE reached 88.46%. The given average value of the OEE indicator ranked the device according to Cercós et al. (2019) into a higher group with values of the OEE indicator ≥ 85% < 95%, which is characterized as a good level with good competitiveness and according to the American company Lean production into a world class group with an OEE value above 85%, which is considered long-term the goal of many companies. The aim of the article was to increase the efficiency of the veneer gluing line equipment by identifying the main downtime losses in furniture production, such as identifying the causes of critical equipment downtime, analysing quality discrepancies due to machine malfunctions, and analysing the overall efficiency of the equipment OEE. We are not aware of the existence of studies using a combination of the mentioned methodology in the conditions of the furniture industry. Continuous monitoring of downtimes and their causes through monitoring of OEE levels makes it possible to discover opportunities to improve the performance of production processes, contributes to their agility and higher competitiveness.

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REFERENCES

1. Almeanazel O. T. R. (2010): Total Productive Maintenance Review and Overall Equipment Effectiveness Measurement. Jordan Journal of Mechanical and Industrial Engineering. 4, (4) pp.517 – 522.
2. Andersson, C.; Bellgran, M. (2015): On the complexity of usingperformance measures: Enhancing sustained production improvement capability by combining OEE and productivity.Journal of Manufacturing Systems, 35: p. 144-154.
3. Binti Aminuddin N. A; Garza-Reyes, J. A.; Kumar, V. et al. (2016): An analysis of managerial factors affecting the implementation and use of overall equipment effectiveness. International Journal of Production Research, 54(15), pp. 4430-4447.
4. Cercósa, M. P.; Calvob, L. M.,; Domingoa, R. (2019): An exploratory study on the relationship of Overall Equipment Effectiveness (OEE) variables and CO2 emissions Procedia Manufacturing 41, pp.224–232.
5. Dal, B.; Tugwell, P.; Greatbanks, R. (2000): Overall equipment effectiveness as a measure for operational improvement: a practical analysis, International Journal of Operations & Production Management, 20(12) pp. 1488-1502.
6. Garg, A.; Deshmukh, S. G. (2006): Maintenance management: literature review and directions, Journal of Quality in Maintenance Engineering, Vol. 12 No. 3, pp. 205-38.
7. Gomes, C. F.; Yasin, M.M. ; Lisboa, J.V. (2006): Performance measurement practices in manufacturing firms: an empirical investigation, Journal of Manufacturing Technology Management, Vol. 17 No. 2, pp. 144-67.
8. https://4industry.consulting/
9. Jeong, K., Phillips, D. (2001): Operational efficiency and effectiveness measurement, International Journal of Operations & Production Management, 21(11) 1404-1416.
10. Jesse. N. (2019). Agility eats legacy - the long good-bye. IFAC-PapersOnLine. 52 (25) (pp. 154-158. 10.1016/j.ifacol.2019.12.464.
11. Kumar, P.; Varambally, K. V. M.; Rodrigues Lewlyn L.R. (2012): A Methodology For Implementing Total Productive Maintenance in Manufacturing Industries–A Case Study" International Journal of Engineering Research And Development, Volume 5-2.
12. Ljungberg, O. (1998): Measurement of overall equipment effectiveness as a basis for TPM activities, International Journal of Operations & Production Management, 18(5495-507.
13. Muchiri, P., et al. (2011): Development of maintenance function performance measurement framework and indicators. International Journal of Production Economics, 131(1): p.295-302.
14. Singh, S.; Kumani, D.; Parkash, V. (2013): Total Productive Maintenance, International Journal Of Scientific Research, Vol. 2:2.
15. Zammori, .F.; Braglia, M.; Frosolini, M. (2011): Stochastic overall equipment effectiveness. International Journal of Production Research, 49(21): 6469-6490

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THE ROLE OF WOOD BIOMASS IN SLOVENIA'S GREEN TRANSITION

Andrej Senegačnik

Abstract: Slovenia is a very forested country, share of forest is equal to 58%. The current energy use of wood fuels is 544.4 ktoe which represents almost 10% of the country's energy supply. The ambitious environmental plan of the European Union is the "Green Deal", which envisages that EU countries will achieve zero greenhouse gas emissions by 2050. Each EU country has drawn up its own national strategy, which predicts several different scenarios for achieving climate neutrality in 2050. The article analyses the Slovenian measures and strategy for the use of wood fuels for energy purposes. The national plan does not demand the excessive use of wood for energy purposes and remains within reasonable limits of sustainable forest use. The forecast for processing biomass into synthetic fuels is rather more optimistic.
Keywords: wood fuels, forest, green transition, national energy and climate plan.

1. INTRODUCTION

The last environmental conference COP28 brought several agreements, including a commitment to abandon fossil fuels. The media, politics, many international forums are full of plans, strategies and commitments to reduce greenhouse gas emissions (GHG) and prevent further warming of the planet. Politicians and environmental protesters have extremely ambitious demands regarding the limitation of greenhouse gas emissions, because they are completely convinced that mankind is the only one to blame for climate change and that we can influence the planet's climate by changing our behaviour? The very demanding environmental plan of the European Union (EU) is the "Green deal" - it assumes that the EU countries will achieve climate neutrality by 2050 with zero emission of greenhouse gases, the abandonment of fossil (and nuclear) fuels and the transition to renewable energy sources (RES) [2].

Also, the Long-term Climate Strategies of Slovenia [7, 8], a member of the EU, follow European guidelines with the goal of achieving climate neutrality by 2050. Slovenia is a very forested country and therefore the use of wood for energy purposes has been present for centuries. The role of wood in the Slovenian green transition strategies is briefly presented in this article.

2. STRATEGIES FOR ACHIEVING CLIMATE NEUTRALITY

The National Energy and Climate Plan (NECP) [8] of Slovenia is a strategic document that must set goals, policies and actions for the five dimensions of the Energy Union by 2030 (with a view to 2040): 1. decarbonisation GHG and RES, 2. energy efficiency, 3. energy security, 4. the internal energy market; and 5. research, innovation and competitiveness. In order to achieve the goals, several scenarios are created that differ in intensity, as well as in the intended path, e.g. use of nuclear energy or not. Some of the scenario assumptions can be considered very optimistic and somewhat contrary to thermodynamics and permanent raising energy consumption in the past. It is assumed that energy efficiency will increase so much that final energy use will decrease by 30-40% by 2050, Figure 1.

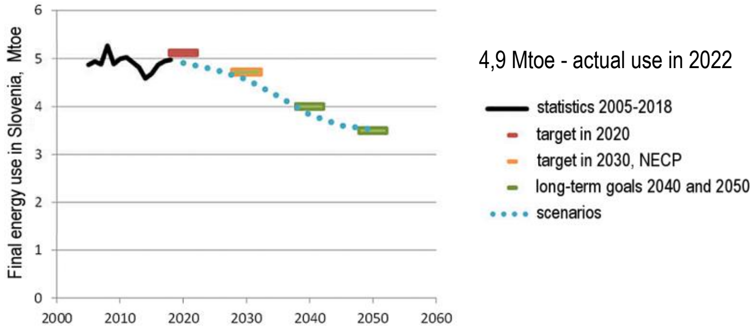

Figure 1. Final energy use in Slovenia – scenarios forecast to 2050 [7]

In some intensive scenarios, forecasts regarding greenhouse gas emissions are similarly very optimistic. As can be seen from Figure 2, negative carbon emissions are also achieved in the very intensive scenario in 2050 through carbon accumulation in wood and other biomass.

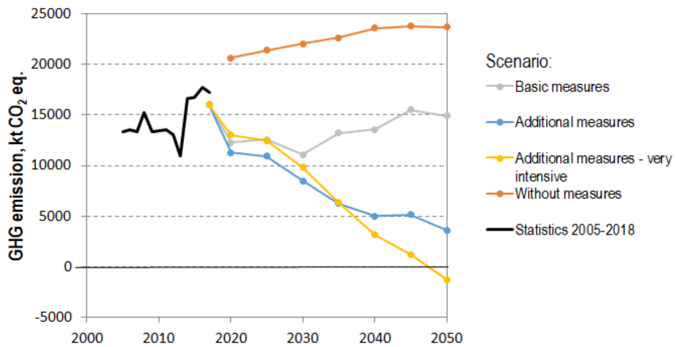

Figure 2. Scenarios forecast of GHG emissions in Slovenia [1]

3. LULUCF SECTOR – LAND USE LAND USE CHANGE AND FORESTRY

The LULUCF sector includes emissions and removals (i.e. sinks) that arise mainly from the use of forest land, i.e. accumulation of CO_2 in wood, as well as due to the use of arable land, grassland, settlements and other land [3]. In the past, the course of net emissions in the LULUCF sector was most influenced by the increase in the area of managed forest land, including the accumulation of wood stocks, which was pronounced until 2007. After 2007, sinks on forest land decrease, as potential and realized felling gradually increase [4]. Initially, this was dictated by a change in the forestry policy, which followed the direction of the national forest program, that the possible cut can reach 75% of the increment. In recent years, the height of actual felling in forests has been significantly affected by natural disasters. From 2014 onwards, a sharp decline in the sink in the sector can be observed, which is the result of natural disasters and related sanitary cuts due to ice breakers in 2014 [14], bark beetle attacks in 2015 and 2016, wind breakers in 2017 and 2018 in Slovenian forests [12]. The goal of the sector under one of the scenarios is a net sink of at least -3,000 kt CO_2 eq in 2050. In doing so, it must be ensured that the change in the carbon stock (calculated as a sink) in the obtained wood products (i.e. sawn wood, wood panels and paper) increases by 100% or to -370 kt CO_2 yearly. Projected emissions of the LULUCF sector are shown in Figure 3 under different scenarios.

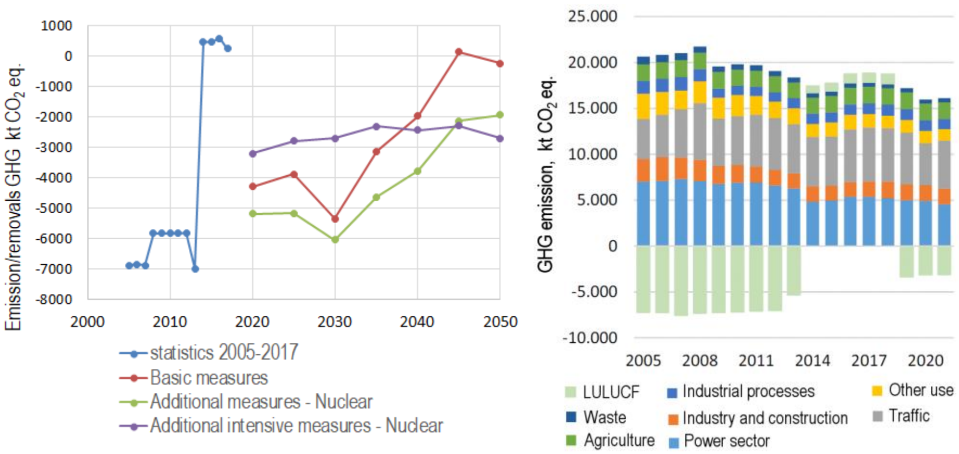

Figure 3. Left: LULUCF sector forecast emissions [1], Right: Cross-sectoral comparison of emissions with the LULUCF sector [8]

Forests cover 58% of the surface of Slovenia. The wood stock of forests in Slovenia is estimated at 357 million m^3 or 303 m^3/ha. The annual increase is estimated at 8,736,972 m^3 or 7.43 m^3/ha. The potential felling at the country level, determined by official institutions, has increased from 3.2 million m^3 (1994) to 7.2 million m^3 (2022). It is estimated that roughly 5.6 million m^3 of wood mass was cut in 2022, or 74% of the allowable cut. The share of sanitary felling reached 31% [11].

4. WOOD BIOMASS

The use of lower quality wood and wood waste for industrial and energy purposes greatly improves the economics of wood processing chains. Wood biomass is of great importance in the production of heat and electricity in district heating systems and industry. In the future wood biomass will be encouraged to be used for energy purposes in a controlled manner and with the highest possible yield and the lowest possible negative impact on the environment with the lowest possible emissions of outdoor air pollutants: particles, polycyclic aromatic hydrocarbons (PAH), etc. The use of sustainably available wood biomass will be prioritized in the gasification of wood biomass with the aim of producing synthetic gas and hydrogen and injection into gas pipeline networks with the aim of minimizing the number of energy conversions and losses of the available potential of wood biomass as well as the co-production of electricity and heat in industry, district heating systems and services, where it is possible to exploit we achieve the maximum overall efficiency of the available heat.

According to statistical data, the production of round wood suitable for energy purposes from forests (firewood category) in 2021 was only 1,115,000 m^3 (net volume), of which

997,000 m^3 were hardwoods and 118,000 m^3 conifers [11, 13]. According to the strategic orientations, which give absolute priority to the processing of wood into products, it will be possible to use only part of the potential of lower-quality round wood and a larger part of wood residues and spent wood for energy production. The needs of the wood processing industry for low-quality round wood are expected to increase to 1,098,000 m^3 by 2025, of which 360,000 m^3 are hardwoods and 738,000 m^3 are softwoods (net volume). In 2021, according to the latest estimates a 980,000 m^3 of wood (net quantity) was used for these purposes. Data on the production of forest wood assortments show how much round wood from forests is directly used for energy purposes. The potentials in forests are higher, since the production of forest wood assortments does not include the amount of small wood (diameter below 10 cm) and the amount of logging residues, and significant potential for energy purposes is also represented by unpolluted wood residues and unpolluted spent wood. According to the data from the wood chipper census conducted in 2021 by the Forestry Institute of Slovenia, the production of wood chips in 2020 was 2,417,000 m^3. According to statistical data, the consumption of wood for energy purposes in 2021 amounted to 2,518,800 t. The potential for obtaining energy from forest biomass is estimated at 6,598 GWh of heat and 326 GWh of electricity [6]. With this, wood will contribute most of the heat (over 90%) and about a third of the electricity from agriculture and forestry sector. Encouraging the co-production of electricity and heat while ensuring useful heat consumption is one of the necessary measures for more efficient use of wood biomass. In large thermal power plants, in addition to the basic energy source, biomass and wood chips are also used as a source of RES. The annual consumption of biomass for these purposes fluctuates and in 2021 reached 123 kt, and the production of electricity 50 GWh. Biomass is becoming competitive with imported coal for the production of heat and electricity, but its use is limited to co-firing on an existing coal plant and not on its own. In the future, it is therefore necessary to support modern and efficient systems for the simultaneous production of heat and electricity in industry, where the demand for both heat and electricity is high throughout the year. Special emphasis should be placed on supporting combined heat and power (CHP) systems in the wood processing industry, where wood residues are produced (wood scraps, bark) and at the same time the need for heat throughout the year is also permanently high (wood drying).

According to NECP, the consumption of wood fuels for this type of use is not expected to increase, Figure 4 (left) [8]. As the energy efficiency of households increases, the consumption of wood fuels is expected to even decrease Figure 4 (right) [8].

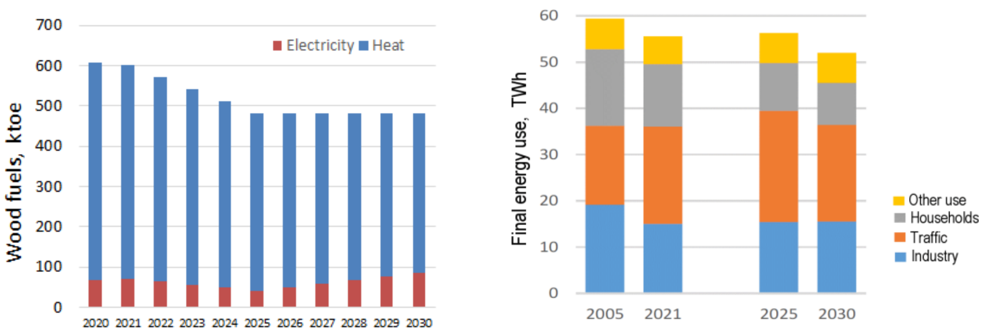

Figure 4. Left: NECP predicted wood fuel consumption. Right: Structure of final energy consumption – considering the current situation, visible savings in households and transport

4.1. Synthetic fuels from biomass

In the future, the use of renewable hydrocarbon synthetic fuels is predicted, which will be obtained from green hydrogen (electrolysis of water) and renewable carbon in the form of CO or CO_2. Any kind of biomass can be used as a renewable source of carbon, including waste wood biomass that is useless for conventional energy use (combustion or processing into wood chips, etc.). Current technology is that the biomass is first gasified with pure oxygen and synthesis gas is obtained from which methane and other hydrocarbons can be further synthesized. This type of process is energy-consuming with an energy efficiency of 30-40% [9]. This means that for the synthesis of 1 GWh of synthetic methane (natural gas), it is necessary to invest ~2.5-3 GWh of energy (of which more than ~80% of the electricity for the electrolysis of water and obtaining pure oxygen for gasification) and ~210 m^3 of air-dried wood as a renewable source of carbon (~54 t). To replace the entire amount of natural gas that Slovenia consumes annually, i.e. ~10 TWh, we would need as much as 2.1 million m^3 of wood (almost the entire annual amount of wood that is currently used for energy use) and an additional ~30 TWh of electricity for synthesis (current electricity consumption is ~15 TWh).

As can be seen, such wishes and strategies of the green transition are technically unrealizable and also technically absurd. In the case of the synthesis of gasoline or diesel fuels, the specific consumption of energy and wood per kg of synthetic fuel increases even more. There are many options for obtaining renewable carbon (or CO_2) for synthesis, but will they make sense [5]? In various IEA scenarios [10], ambient air or sea water is assumed as the source of renewable CO_2 for fuel synthesis. The energy consumption to obtain 1 kg of carbon (in a form of CO_2); from air is ~8 kWh, from sea water is ~6 kWh [9].

5. DISCUSSION AND CONCLUSIONS

The NECP does not envisage a very intensive increase in the consumption of wood fuels for energy purposes (given the current situation), because this could have a negative impact on biocapacity and CO_2 sinks if used inappropriately. The official forestry plans for the period 2021-2030 envisage the continuation of the accumulation of wood stocks in forests, as well as additional measures to improve the structure of forests and their adaptation to climate change. The implementation of measures in connection with felling is limited, in reality less wood is cut than the planned felling, which further increases the sinks from the forests. A very sensible strategy that defines policies and measures for the LULUCF sector - the sustainable management of agricultural land and forest - is to achieve zero growth in built-up areas by 2050 and increase the amount of agricultural land for food production. Forests are managed sustainably. Considering the existing forest management instruments and policies the carbon sinks will probably increase, but it is questionable whether the increase in the sinks will reach the target value of 4.5 Mt. Current projections of net emissions from the LULUCF sector for 2030 range between 3.9-5.1 Mt CO_2 eq.

As the energy efficiency of the utilization of the available wood biomass will increase, the direct use (by combustion) may decrease. Regarding the use of the remaining sustainably available wood biomass, the NECP has optimistic forecasts with gasification and synthesis with green hydrogen into synthetic natural gas, which in reality is very energetically and technologically demanding process.

REFERENCES

1. EU project (2020): LIFE ClimatePath2050 (LIFE16 GIC/SI/000043), *Deliverable C3.2: Summary of Scenario Analysis for Policy Makers for Mid-Century Climate Strategy for Slovenia*, report no. IJS-DP-13286, ver. 1.0
2. European Commission (2019): *European Green Deal*. https://ec.europa.eu/commission/presscorner/detail/en/ip_19_6691
3. European Commission (2021): *New EU Forest Strategy for 2030.* https://commission.europa.eu/document/download/cf3294e1-8358-4c93-8de4-3e1503b95201_en
4. Fidej, G., Rozman, A., Diaci, J. (2018): *Drivers of regeneration dynamics following salvage logging and different silvicultural treatments in windthrow areas in Slovenia*, Forest Ecology and Management, 409, pp 378-389, https://doi.org/10.1016/j.foreco.2017.11.046.
5. Furfari, S.; Mund, E. (2021): *Is the European green deal achievable?* Eur. Phys. J. Plus 136, 1101. https://doi.org/10.1140/epjp/s13360-021-02075-7
6. Government of the Republic of Slovenia (2003-2021): *Energy balance of Republic of Slovenia*. https://www.energetika-portal.si/dokumenti/statisticne-publikacije/letna-energetska-bilanca/
7. Government of the Republic of Slovenia (2020): *Slovenia's long-term climate strategy for 2050* (in Slovene). https://www.gov.si/assets/ministrstva/MOP/Javne-objave/Javne-obravnave/podnebna_strategija_2050/dolgorocna_podnebna_strategija_2050.pdf
8. Government of the Republic of Slovenija (2023): *National Energy and Climate Plan* (in Slovene). https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/nepn/dokumenti/nepn_posod_dec2023.pdf
9. Hänggi, S.; Elbert, P.; Bütler, T.; Cabalzar, U.; Teske, S.; Bach, C.; Onder, C. (2019): *A review of synthetic fuels for passenger vehicles*. Energy Rep. 5, pp. 555–569. https://doi.org/10.1016/j.egyr.2019.04.007
10. IEA Publications (2021): *Net Zero by 2050 A Roadmap for the Global Energy Sector*. https://www.iea.org/reports/net-zero-by-2050
11. Slovenia Forest Service (2023): *Fellings of conifers and deciduos in Slovenia, 1993–2022* *https://kazalci.arso.gov.si/en/content/growing-stock-increment-and-fellings-5*
12. Slovenian Forestry Institute (2021): *State and changes in Slovenian forests between 2000 and 2018: results of large-scale monitoring of forests and forest ecosystems*, https://dirros.openscience.si/Dokument.php?id=18717&lang=slv
13. Statistical Office, Republic of Slovenia (2024): *A billion data points in the SiStat Database*. https://pxweb.stat.si/SiStat/en
14. Unay-Gailhard, I., Bojnec, Š. (2020): *Public support effect on natural disaster management: A case study of ice storms in forests in Slovenia*, Land Use Policy, 95, 103811, https://doi.org/10.1016/j.landusepol.2019.01.014.

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INNOVATIVE PRACTICES AND MULTIFUNCTIONAL APPLICATION OF WOOD MULCH IN EUROPE

Teodorina Turlakova, Gergana Slavova, Tanya Georgieva

Abstract: Wood mulch is mainly obtained from tree bark, wood shavings, pine straw, forest moss and leaves. Natural mulch, on the other hand, can also be produced from grass clippings, hay, leaves, manure, compost and other natural materials. Such a product can be used to decorate paths and parks, and it could be painted with harmless (natural) paints in contrasting colors, sometimes in combination with colored pine cones of various shapes and sizes. The great advantage of wood and natural mulch is that within four to five years it turns into compost that nourishes the soil, in a completely natural way. The purpose of this paper is to investigate the factors that stimulate and hinder the implementation of innovative practices in the agricultural sector, based on natural wood mulch in Bulgaria, as well as to compare it with its multifunctional application in other European countries. A method of analyzing diffusion of innovation, comparative analysis, along with methods of induction and deduction were used. The results can be applied by various forestry, agricultural, constructions, educational, industrial and commercial companies, agricultural producers, scientists and researchers in the field of forestry and agriculture sector, as well as by farmers and agrarian specialists.
Keywords: wood mulch, natural mulch, agriculture, forestry, tree bark, agribusiness

Many factors influence management decisions and management actions in the agricultural sector. Mulching is a very important part of ecological and nature-friendly farming, carried out in vegetable and fruit gardens. It is characterized by placing a specific cover on arable plots of land in order to create benefits for the soil and preserve the integrity of plant roots. Mulching is part of the green economy(Zhang, 2022). At the same time, the role of mulching as a strategic solution in the sustainable management of the agrarian business, with which to preserve moisture in the soil and to protect cultural plants from weeds, is essential (Altieri, 2004). Part of the main factors affecting the agrarian sector are directly related to the very specifics of the production process, such as the production of biologically living organisms, the direct impact of natural-climatic factors and agricultural land as the main production factor in the agrarian sector (Slavova, 2019). Along with them, like other sectors of the world economy, the factors of capital, innovation, entrepreneurship and workforce are used as economic resources to create goods. In parallel, there are a number of factors that have a strong impact on the diffusion of innovations in agribusiness (Georgieva, 2018). These factors can be divided into two main groups, with the first group of factors covering primary and secondary characteristics of the innovation. The diffusion of innovations in agriculture is significantly influenced by drivers such as the comparative advantage of technology. Sustainable agriculture is based on integrated management solutions and organic guidelines in agribusiness (Bavec, et all, 2009). In our particular case, compatibility, complexity, and the ability to test mulching in agriculture, as well as the ability to monitor the results of implemented mulching technology in other farms or other types of sectors of the economy, are the main comparative advantages of the technology. Primary innovations related to mulching are characterized by costs of acquiring the necessary mulching materials, which can be, for example, organic materials (herbaceous or woody, often obtained from the shredding of plant residues, including wood, grass, cones, hay, etc.), the use of special mulching sheets of synthetic or bioplastic films or of natural fibers. In fact, mulching is not a management trick, it has existed for millions of years in nature and bare soil is very rarely found in natural ecosystems. All trees, including conifers, change their leaves and thus form a gradually growing layer of organic matter at their base. This layer is called natural mulch. Biological mulch, on the other hand, can be from tree bark, hay, dry leaves, grass clippings, shredded pine bark, biodegradable cardboard or bioplastic films, synthetic non-woven fabric from jute fibers, even sand, short hemp fibers, stones most already for succulent plants, pine needles (applicable, for example, to strawberry plantations). In global agricultural practice and in Europe, wood shavings or small wooden pieces, suitable for shaping paths or rock gardens, are mostly used. Mulching is very important for plant health, but also for soil fertility. Mulching materials can also act as natural fertilizers. These in turn help the soil to recover to its basic structure and become much more productive as arable land.

Mulching is appropriate in any area and in almost within all types of agricultural activity (Hilhorst, 1990). This is why the use of organic mulching methods is recommended. Table 1 summarises the main organic as well as some synthetic mulching materials. Their application is much more ecologically sound and sustainably justified (Hobbs et all, 2011).

Table 1. Basic organic and inorganic mulching materials

	Types of mulching materials	*Main representatives of mulching materials for Europe*
1	*Basic organic mulching materials*	*Hay (cut grass); Straw and stems; Leaves of all kinds of trees and shrubs; Pine leaves and bark from the pine trees trunks fallen in the forests; Sawdust residues and lumberyard wood scrap; Wood chips specially developed for organic mulching; Some cover plants such as clover, vetch, beans, etc.*
2	*Inorganic mulching materials*	*Pebbles and larger stones, pumice, wool, woven fabrics, mulching paper, black or clear polyethylene, nylon, plastic sheets and foil;*

Mulching prevents many negative results in agriculture. It is among the best forms of adaptive management, taking into account the ecological aspects of environmental protection. (Berkers et all, 2000) Part of the negative consequences that mulching overcomes are weed control and soil erosion. Forage crops such as clover and fenugreek can be planted for mulch when growing fruit trees. In the recent past, mulching was mostly biodegradable or organic materials, today, unfortunately, it is increasingly synthetic materials and plastic or nylon coverings are found in yards and gardens. However, these covering materials do not have any effect on the physical structure of the soil, they only facilitate harvesting and prevent weeds. The role of knowledge, skills and perceptions of agricultural workers is very important in introducing the mulching process (Seline, 2015). Inorganic materials are not a natural type of soil fertilizer and unlike natural mulching materials do not improve soil structure. For large areas of agricultural land, it is advisable to use organic mulching materials, such as straw and sawdust, which are placed around the cultivated plants by special machines. Table 2 presents the main advantages of mulching along with some of its disadvantages.

Table 2. Advantages and disadvantages of organic and inorganic mulching

	Benefits of mulching in agriculture with organic materials	Disadvantages of mulching in the agricultural sector with inorganic materials
1	Prevents soil water loss	Sometimes artificial materials such as nylons and polyethylenes steam the soil
2	Provides significant weed control	Partially provide weed control
3	The soil warms up more and this is favorable for spring crops	The soil can sometimes overheat from the use of black films and polyethylenes
4	Prevents wind erosion	It does not reduce wind erosion
5	Reduces water erosion damage	It does not prevent water erosion
6	Adding organic matter to the soil	It does not add organic matter to the soil
7	Encourages the production of humus in the soil	Accumulation of harmful and non-degradable materials in the soil

The secondary characteristics of innovation through the application of mulching in agriculture and the agrarian sector, as comparative advantages with respect to the non-application of mulching techniques, are mostly based on:

- preventing weed growth by blocking sunlight and its penetration into the soil;
- conserving additional water input to the soil by reducing or preventing evaporation from the surface of the top layer of the soil;
- preventing root system of crop plants from being exposed in the soil and preventing against wind and water erosion;
- in addition to all the above, a huge advantage of mulching as a specific process applied in agriculture is that it promotes the biological activity of crop plants, as it reduces direct sunlight and retains moisture, and also adds organic matter and nutrients to the soil, when the mulch is made of biodegradable materials.

The comparative advantage of mulching is the degree to which a given technological system (in this case mulching) is perceived as better compared to growing crop species without mulching. A survey was conducted among 25 farmers in North-Eastern Bulgaria to find out if they implement the practice and if they consider mulching and ecological production to be preferable to conventional farming. The answers obtained were more than surprising. 100% of the surveyed farmers confirmed that they believed in the comparative advantages of applying mulching on their own farms and environmentally friendly production methods, but only 50% applied mulching on their personal farms. When asked what hindered the remaining 50% from applying this innovative technology, they replied in several ways: for the 25% who do not apply, the main problem is finding additional time and resources to acquire the necessary organic mulching materials. For 13%, the problem is the lack of enough wood shavings in the area and their desire to use exactly wood and not grass mulch, and 12 could not clearly indicate what exactly prevents them from implementing this ecological and relatively innovative technology for the country. Some of the respondents pointed out that the additional costs are what deter them from doing mulching. A large number of those who do not apply it have never thought about the process of financial return on investment, related to, for example, halving costs in the future, or the lack of shading with special nets placed on pre-placed supports over growing cultural plants. A large number of those implementing the mulching technology in their personal farms responded that they were very satisfied with the results, but especially with their choice to apply this relatively innovative mulching technology. Moreover, they pointed out that mulching is easily compatible as an innovative process with their agricultural activities, and it does not require to be applied to all the plants. Mulching also reduces potential pests on cultivated plants, it is easy to implement and does not require any new and high technological knowledge, as is required, for example, when applying automated or robotic processes in the agricultural sector (Seline, 2015). Another huge advantage is the ability to observe the effect of this technology in practice. The possibility for the farmer to directly observe the results of the mulching, in our opinion, will significantly increase the probability of the implementation of mulching on the territory of agricultural holdings in the future. A key stimulus for the introduction of mulching in the agricultural sector is the Common Agricultural Policy of the European Union and its direct and indirect influence, through the environmental measures to the rural development program. This is because the policy significantly stimulates the green transition and the development of ecological agriculture, and mulching is part of this process. It is a specific activity performed in agriculture and horticulture, which is carried out by covering the soil with a specific layer of material to prevent the growth of weeds, to maintain moisture in the soil, to protect the soil from erosion, as well as from the action of various swamps or floods in consequence of very heavy rains. Through it, the formation of the so-called surface crust is avoided, thus reducing compaction and maintaining the soil structure in the best possible condition, as well as mitigating the temperature amplitudes from cooling or strong heating of the soil. Mulching can be applied with great success not only in agricultural activity, but also in the creation of specialized wooden mulched children's playgrounds, playgrounds and sports facilities, park spaces, alleys, recreation areas in industrial companies, where it is possible to also uses mulch developed from synthetic and not only biological materials. (Hamilton, 2021). The technique of mulching in the agrarian sector allows resistance to higher temperatures at the root level, while reducing the need for watering during the hot months. It is a specific method widely used in sustainable agronomic practices, for example in the creation of permaculture, natural farming and biodynamic farming. Mulching is a specific operation that must be carried out between the months of November, December, January and February. The entire area needs to be dug up very well, this way it remains soft and loose during the winter so that new plants can appear in the spring. The best type of mulch is wood chips, it consists of using chopped wood logs or large sawdust. A bioshredder or biochipper is usually used for this purpose. In agricultural practice, a technique called living or green mulch is also often applied. It is applied when the cultivated plants are stronger with their roots than the grasses that surround it, thus the grasses themselves or spices and herbs play the role of mulch. When weed grass is used that has not yet dried, it is called fresh mulch. The mulch is applied with a thickness of 5 to 10 cm, it can be adjusted according to the needs of the cultivated plants.

Multifunctional use of resources is closely related to diversification of activities in the field of not only agriculture, but also forestry, sports, health care and tourism business(Turlakova,2014). The application of waste products from the forestry sector, such as wood shavings, wood chips or wood cubes in the agricultural sector as organic mulch, and also in the sports, education, tourism sectors, as suitable flooring on sports and children's playgrounds, on walkways and rock gardens, demonstrates multifunctional use of forest sector resources and their good strategic management. Mulching is also used with great success outside of agriculture to cover playgrounds, sports grounds, park spaces and paths with organic materials, using most often wood chips or colored wood shavings, but quite often inorganic materials, such as shredded and colored car tires, as well as specific plastic pavements or nylon sheets covering the ground. Other non-plant mulching materials are: sand, stones and gravel. Millions of Europeans play on sports fields and pitches every day in all weather conditions. For their flooring, plastic or rubber granules are used as a material to create a soft surface. The soft filling makes the playgrounds more durable and weatherproof, and also absorbs more shocks and offers more traction. Even for playgrounds, the surfaces under swings, slides and other structures are covered with loose rubber mulch to make the ground softer and thus cushion falls. Granulated mulch is often made of used car tires, shredded and cut into smaller pieces. Their use as an infill in synthetic grass has increased over the last 15-20 years due to the rise of these synthetic products and also the EU ban on landfilling waste tires. Pellets and mulch can contain potentially harmful chemicals, including polycyclic aromatic hydrocarbons, metals and phthalates. They can also emit volatile and semi-volatile organic hydrocarbons. They also contribute to microplastic pollution, as they can spread into the environment from playgrounds, for example through rainwater. That is why in recent years the EU has taken measures to improve the ecological footprint of children's playgrounds, playgrounds and sports grounds, such as introduces regulations and bans on the use of excessive amounts of harmful inorganic materials to protect European citizens from dangerous chemicals found in the filling material. One possible solution to this problem is to use more organic mulching materials, such as sawdust. We can point out an extremely innovative practice based on product diversification successfully implemented in North America and Europe. It is based on the use of wood mulch mixed with manure and colored with natural bio-dyes. The application of mulching not only in agriculture, but also in the covering of other areas, such as park spaces, alleys and sports facilities, is observed both in Eastern and Western Europe. It is most widespread in the North-Western countries of Europe, such as Denmark, Sweden, Norway, but it is also observed in developed countries, such as Germany, France, Italy, England and Spain. It is also very popular in Turkey in its Mediterranean region (Antalya, Mugla), in the Aegean region (Izmir, Ayden) and in the Southeast region of Anatolia (Şanlıurfa, Gaziantep). The application of mulching throughout Europe and Turkey is favored by the EU CAP. For example, during the last program period, afforestation was stimulated against subsidies; preservation of soil fertility against compensatory aid to farmers, leaving land fallow;

subsidized cultivation of nitrogen-fixing protein crops, all aimed quite appropriately at ensuring the biodiversity and uniqueness of Europe's native nature and landscape. Mulching is one of the most nature-friendly methods in agriculture, and its multi-functional application in other areas also shows unequivocally that man will always learn from nature and apply the lessons learned in practice.

REFERENCES

1. Altieri, M.A. (2004): *Linking ecologists and tradicional farmers in the search for sustainable agriculture.Frontiers in Ecology and the Environment*, 2 (1), 35-42
2. Bavec, M., Malkar, S. G., Rozman, C., Pazek, K.,& Bavec, F.(2009): *Sustainable agriculture based on integrated and organic guidelines&understanding terms: The case of Slovenian development and strategy.* Outlook on Agriculture,38 (1), 89-95
3. Berkers, F., Colding, J.& Folke, C.(2000): *Rediscovery of traditional ecological knowledge as adaptive management.* Ecology, 7 (1-2), p.55-63
4. Hamiltan, N., (2021*): Granules and mulches on sports pitches and playgrounds*, su echa.europa.eu. URL consultato il, 25 dicembre 2021.
5. Hilhorst, J., (1990): *Regional and Rural development*, Hardbask,p.19.
6. Hobbs, R., J., Hallett, L.M., Ehrlich, P. R.,& Mooney, H.A. (2011): *Intervention ecology: applying ecological science in the twenty-first centкry.* BioScience, 61(6), 442-450
7. Seline S. M. (2015): *The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa.* International Journal of Agricultural Sustainability, Vol. 13, Iss. 1, 2015
8. Georgieva, T. (2018*) Inovatzii v agrobiznesa*. Nauka i ikonomika.
9. Slavova, G. (2019) *Spetzifichni faktori na vazdeistvie pri upravlenie na selskite raioni pri savremenni tendentzii na razvitie,* 78 (5) p. 45
10. Turlakova,T.*(2014), Integrated development through diversification and multifunctional use of resources. Journal of the Union of Scientists - Varna. Ser. Economic Sciences , pp. 28-34.*
11. Zhang, Z. (2022), *Evolution paths of green economy modes and their trend of hypercycle economy. Chinese Journal of Population, Resources and Environment, 20(1), 1-11*

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THE ROLE OF WOOD BIOMASS IN SLOVENIA'S ENERGY SECTOR

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Abstract: Mankind has been using wood for energy purposes since ancient times. Slovenia is a very forested country. The energy use of wood, 544.4 ktoe, represents almost 10% of the country's energy supply, despite the fact that the annual felling is only 50% of the annual growth. The simplest energy use of wood by combustion can also have negative impacts by polluting the surrounding air. In a poorly managed combustion process, at too low temperatures and insufficient combustion air, harmful emissions of particles and toxic organic polycyclic compounds are produced. This kind of inadequate combustion of wood fuels in households is the main source of particles PM10, PM2.5 and organic compounds in Slovenia. The largest share of energy use of wood fuels are represented by households with 57%, processing industry 26%, district heating 9% and electricity production 8%.
Keywords: wood fuels, particle emission, combustion, energy use

1. WOOD FUELS IN SLOVENIA

Mankind has been using wood fuels as sources of energy since ancient times. Until the middle of the 18th century, wood and charcoal were humanity's main energy sources. The use of coal and the invention of the steam piston engine made the extraordinary technological development of mankind possible and, at the same time, an exponential increase in the energy use. Since ~1850, energy consumption per person has been steadily increasing. The primary energy we use globally now, mostly comes from fossil sources, over 85%, and only 15% is renewable. Being aware of the limited fossil fuel reserves and the harmful environmental consequences of such intensive use of fossil fuels, we try to replace this energy with renewable energy, which also includes the sustainable use of wood fuels. Slovenia is a land of forests. Forests cover 58.0% of the state area, the annual growth of wood is ~3.5 m^3 per inhabitant. In terms of forest cover, Slovenia ranks third in the European Union, after Sweden and Finland.

In this article, the use of wood fuels in Slovenia is analysed in relation to the permissible annual cut.

2. CONSUMPTION OF WOOD FUELS IN SLOVENIA

Wood is an important energy source in Slovenia. Traditionally, wood was a source of energy for heating and powering various smelters and metallurgical plants. The oldest world-known metallurgical plant in Slovenia was definitely the world-famous mercury mine in Idrija, which operated from the 16th to the 20th century, mostly using wood as fuel and as support wood in the mine. The consumption of primary energy in Slovenia for the year 2022 is 276.4 PJ or 76.8 TWh, of which the energy use of wood represents 8.2% or 6.3 TWh (544 ktoe) [6, 13]. If we subtract the 50% Croatian share of energy from the Krško nuclear power plant in the energy supply, the energy share of wood already represents 9.3% of the country's energy supply.

The use of wood as an energy source, in addition to water energy, is the most important domestic renewable energy source in Slovenia (Figure 5) for covering heat needs in households, heat production in industry and also some electricity production. The use of wood for energy purposes can have a negative impact on air quality, which is why the use of high-quality wood fuels in modern heating devices is crucial.

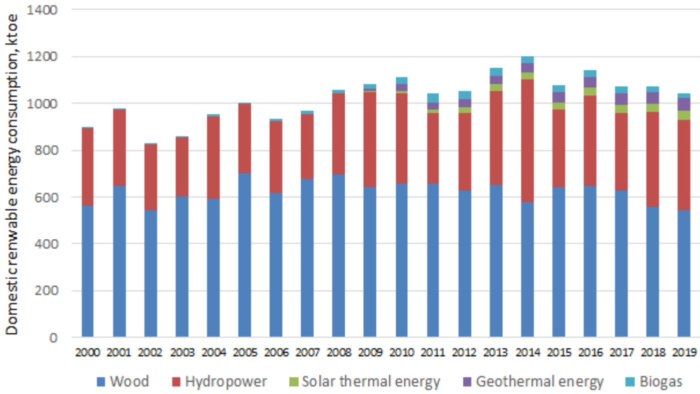

Figure 5. Renewable energy consumption in Slovenia [6, 13]

Most wood fuels in the form of dry firewood are used in rural areas for heating. Most of these fuels also come from own forests. In recent years, there has been an increasing interest in the use of wood pellets for heating, because the comfort of heating is almost the same as with other fossil energy sources.

In Slovenia, forests have been growing stronger for many decades in terms of wood stocks and growth. In the last 70 years, they have increased by more than 140%. Felling, in addition to natural factors, also depends on socio-economic factors, and recently mainly on the occurrence of natural disasters (windfalls, icefalls) and bark beetle pests.

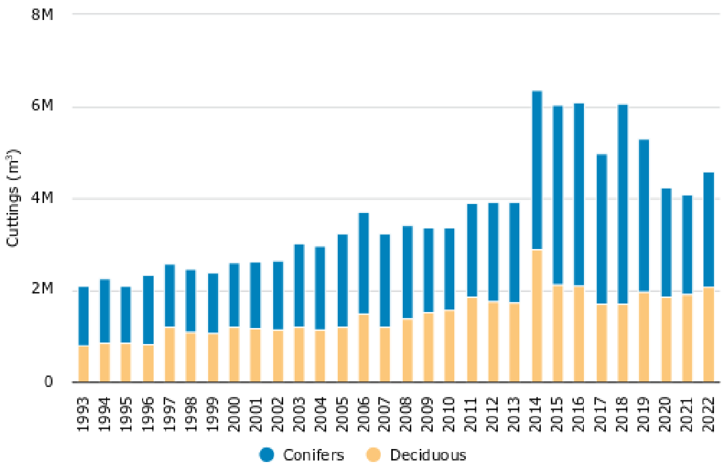

Figure 6. Felling of conifers and deciduous in Slovenia, 1993–2022 [11]

Until 2014, felling accounted for approximately 50% of the growth, but after that year it significantly increased due to damage and accounted for 60 to 75% of the total growth of conifers and hardwoods. It has declined again in recent years and is back to around 50% growth. In 2020, the total felling represented 59% of the possible felling according to forest management plans, of which as much as 42% was sanitary felling [11], Figure 3.

3. ENERGY USE OF WOOD

3.1. Emissions of particles and PAHs

The current problem with the use of wood in small individual fireplaces is excessive air pollution with particles and unburned organic compounds. This is especially problematic during unfavourable weather conditions - inversions. A pressing problem is the problem of small local discharges, which reveal the bad habits of the inhabitants. Burning in outdated heating devices in households is the main source of particle pollution in winter [2, 3, 4, 9]. Burning with unsuitable fuels (e.g. old paper and cardboard, damp moist wood, plastic, packaging and other waste) and improper burning with inadequate air ratio and inadequate furnace are particularly problematic. All of this causes extremely poor and incomplete combustion of wood biomass, producing large amounts of particles and toxic organic compounds PAH (polycyclic aromatic hydrocarbons) [2,10]. Such inadequate combustion is visible from afar, when thick black or white smoke comes out of the chimney and eventually disperses in the near and far surroundings. Unfortunately, such a situation in a city or a village can be caused by a single unconscious smoker. A typical Slovenian problem is also that the surrounding residents are powerless to prevent this type of individual pollution through the appropriate state institutions (inspectors, chimney sweeps, etc.). The results of the analysis of the origin of the particles are very clear - Figure 7. Most of the particles originate from individual fireplaces. Despite everything, it is positive that the emissions of PM10 and PM2.5 particles decreased by 29% and 20% in the period 2000-2021 [5]. Figure 7 also shows that individual fireplaces are one of the main sources of particles in other EU countries as well. Figure 8 shows that small households' combustion is also the main source of PAH in Slovenia [6].

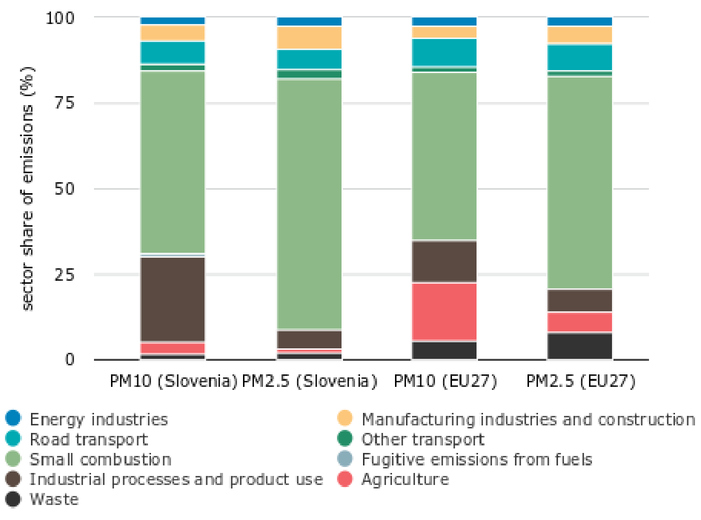

Figure 7. Particle emissions in Slovenia and EU-27, 2021 [5]

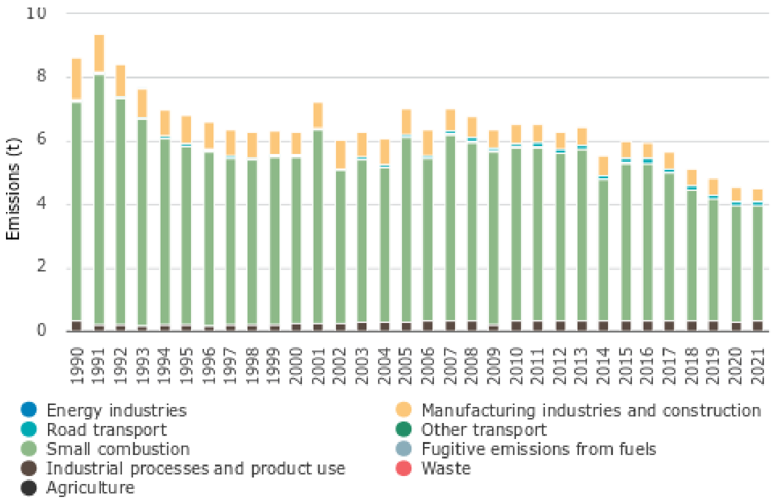

Figure 8. Sources of polycyclic aromatic hydrocarbons (PAH) emissions in Slovenia [6]

Figure 9 shows the emissions of PM10 – PM2.5 particles per capita in the EU-27 in 2021. As can be seen, the emissions in Slovenia are among the highest in Europe, which is not good. If we compare the emissions in Austria or Sweden, where the individual consumption of wood fuels per capita is similar, we notice significantly lower emissions. The positive message of Figure 5 is that excessive emissions in Slovenia can be significantly reduced with proper and conscious combustion in modern heating devices. For better air quality, it will be necessary to educate households and replace outdated heating devices.

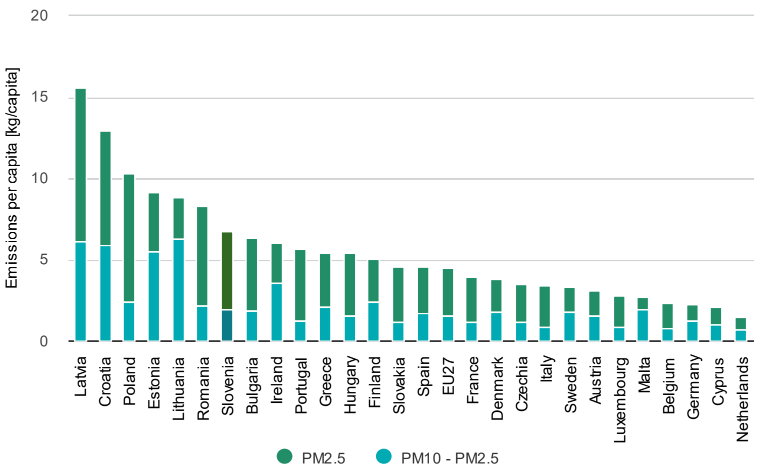

Figure 9. Particulate matter, PM10 – PM 2.5, emissions per capita in EU-27 in 2021 [5]

3.2 Industrial use and production of electricity

The current use of wood fuels in industry is primarily limited to paper mills, the wood processing industry, the chemical industry, and the industry of non-metallic mineral products, i.e. construction material. The total consumption of wood fuels in industry was ~234 ktoe in

2022. Recently also floating bed boilers have been appearing in the industry, which can use wood fuels of lower quality, e.g. fresh remnant of forest felling. Most of the industrial use is the use of wood chips. Wood chips are mostly used in hot water boilers of various district heating systems and also steam boilers for the production of superheated steam. For example, in Ljubljana's power and heat plant, the annual consumption of wood chips is ~100,000 tons, which is ~21.5 ktoe. The share of wood fuels in Slovenian district heating systems is 21.6%, which means ~566 GWh (48.7 ktoe) of energy from biomass.

The production of electricity from wood fuels is relatively small and is limited to smaller privately owned combined heat and power (CHP) systems that are included in the subsidy scheme and a few larger system cogeneration plants like Ljubljana's heat and power plant. Currently, there are only 38 systems left in the support scheme with a total power of ~35 MW, annual production of electricity 122.2 GWh and support subsidies of 11.5 million EUR. This roughly means that the state subsidy is ~95 EUR/MWh? Since the technology of producing electricity from biomass is relatively demanding, (too) expensive, demanding for operation and for maintenance (classic steam cycle or gasifier and wood-gas engine), interest in setting up such systems is declining. A common characteristic of the production of electricity with smaller (thermal) systems is that such systems become competitive only at higher powers, above 10 MW, which is inaccessible to the private sector in terms of investment. The total production of electricity from biomass in 2022 was 159 GWh, which represents ~1% of required amount of electricity in Slovenia, which is currently ~15 TWh (consumption + transmission/distribution losses). Wood fuels energy balance for Slovenia is presented in Table 1.

Table 1. Wood fuels balance in Slovenia, 2022 [6, 13]

	Energy, ktoe	Share, %
Wood fuels - Total	544,4	100
District heating	49	9
Manufacturing industry	139	26
CHP use - electricity	46	8
Households	310,4	57

4. CONCLUSIONS

As can be seen from the energy balance of wood fuels, the total industrial consumption represents only 43%, the largest consumption of wood fuels is still represented by households for heating buildings and sanitary water. Consumption in the manufacturing industry could be higher. Considering that the current annual felling represents only 50% of the possible, at least additional ~540 ktoe wood energy is available for energy use. This is good from the point of energy self-sufficiency. How this surplus wood will be transformed to the energy in the future is still quite unclear. Considering the politically (over)forced green transition, which has already begun to break in Europe, the wishes of green activists to process wood into synthesis gas and other apparently more environmentally acceptable forms are very great.

Thermodynamics teaches us that any conversion of energy, matter,... requires an input of energy, and the conversion always leaves a trace in the environment, which is the result of process losses. All real processes are irreversible. In terms of the green transition, the entire society should strive for a prudent and frugal way of life, which unfortunately is in complete contradiction to the current doctrine of constant economic growth and free market economy.

Wood is a wonderfully versatile and renewable material that deserves to be used wisely. If it is used for energy purposes, it is necessary to provide suitable conditions during combustion, sufficiently high temperatures and enough combustion air, so that air pollution with the resulting flue gases is as small as possible.

REFERENCES

1. Government of the Republic of Slovenia (2003-2021): *Energy balance of Republic of Slovenia*. https://www.energetika-portal.si/dokumenti/statisticne-publikacije/letna-energetska-bilanca/
2. Han, Y., Chen, Y., Feng, Y., Song, W., Cao, F., Zhang, Y., Li, Q., Yang, X., & Chen, J. (2020): *Different formation mechanisms of PAH during wood and coal combustion under different temperatures*. In: Atmospheric Environment (1994) 222, 117084
3. Kirchsteiger, B.; Kubik, F.; Sturmlechner, R.; Stressler, H.; Schwabl, M.; Kistler, M.; Kasper-Giebl, A. (2021): *Real-life emissions from residential wood combustion in Austria: From TSP emissions to PAH emission profiles, diagnostic ratios and toxic risk assessment.* In: Atmospheric pollution research 12 (8): 101127
4. Mothes, F., van Pinxteren,D., Spindler, G., Löschau, A. Hausmann, & Hartmut Herrmann. (2020): *Partikuläre Emissionen aus der Holzverbrennung und ihr Beitrag zu PM/Particulate emissions from wood burning and their contribution to PM*. In: Gefahrstoffe, Reinhaltung Der Luft = Air Quality Control 80, pp. 305–317.
5. National Emission database, Slovenian Environment Agency (2023): *Emissions of particulate matter*, https://kazalci.arso.gov.si/en/content/emissions-particulate-matter-9
6. National Emission database, Slovenian Environment Agency (2023): *Emissions of persistent organic pollutants in Slovenia, 1990 – 2021.* *https://kazalci.arso.gov.si/en/content/persistent-organic-pollutants-emissions-pops-2*
7. Slovenia Forest Service (2023): *Fellings of conifers and deciduos in Slovenia, 1993–2022* *https://kazalci.arso.gov.si/en/content/growing-stock-increment-and-fellings-5*
8. Statistical Office, Republic of Slovenia (2024): *A billion data points in the SiStat Database*. https://pxweb.stat.si/SiStat/en
9. Trubetskaya, A., Lin, C., Ovadnevaite, J., Ceburnis, D., O'Dowd, C., Leahy, J. J., Monaghan, R. F. D., Johnson, R., Layden, P., & Smith, W. (2021): *Study of Emissions from Domestic Solid-Fuel Stove Combustion in Ireland.* In: Energy & Fuels 35 (6), pp. 4966–4978.
10. Vishwakarma, P., Rajeev, P., Rabha, S., Islam, N., Saikia, B. K., & Gupta, T. (2023): *Wintertime trends of particulate-bound polycyclic aromatic hydrocarbons (PAHs) at north-east site of India: chemical characterization and source identification*. In: Journal of Atmospheric Chemistry 80 (4), pp. 251–269.

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NEW MARKET TRENDS, LOGISTIC SERVICES AND INNOVATIVE TRADE PERSPECTIVES

CHANGES IN CROATIAN WOOD PRODUCTS MARKET IN RESPONSE TO SUSTAINABLE DEVELOPMENT

Jelena Obranković, Andreja Pirc Barčić, Darko Motik, Petar Ćurić, Živka Meloska, Denis Jelačić

Abstract: The wood industry plays an important part in today's world economy, while wood products play an important role in ensuring sustainable consumption and production. Eurostat data from 2020 shows that in the European Union, wood-based industries accounted for 19,00% of all manufacturing enterprises. Consequently, the wood-based sector continues to be a crucial component of the broader manufacturing landscape within the EU. Additional, Croatian wood industry play an important part in the EU economy it holds a prominent position among the leading countries in the production and export of wood products. When analyzing production, Croatia consistently ranks as one of the top producers among EU countries it maintained its status as one of the largest producers in the EU. The aim of this paper is to analyze changes in Croatian wood products market in response to sustainable development incentives based on production, export and consumption information.

Keywords: wood products; market analysis; Croatia; sustainable development

1. INTRODUCTION

The wood industry plays an important part in today's world economy, while wood products play an important role in ensuring sustainable consumption and production (Epede and Wang, 2022). Eurostat data from 2020 shows that in the European Union, wood-based industries accounted for 19,00% of all manufacturing enterprises. Consequently, the wood-based sector continues to be a crucial component of the broader manufacturing landscape within the EU. Croatia is one of the leading countries in the production and export of hardwood, according to European Organization of Sawmill Industry (EOS) (2023) and EUROSTAT (2022).

According to Forest management plan, the total area of forests and forest lands in Croatia is 2,76 million ha, which is 49.3% of the land area of the country. Of this, 2,1 million ha are public owned forests, while 661,721 ha are owned by private forest owners. The majority of forests owned by the state are managed by the public forest owner company. According to available data a total amount of wood stock is 418.6 million m3. Croatian wood-based industry has been developed on high quality forest raw material and as such, it represents an important economic segment of the country. When examining production, Croatia consistently emerges as one of the top producers among EU countries. In 2020, Croatia produced 1,066,886 m³ of sawn hardwood. The following year, production slightly decreased to 1,041,613 m³. Nevertheless, Croatia maintained its position among the largest producers in the EU, surpassing Romania (with 1,700,000 m³ in 2021 and 1,615,000 m³ in 2020), France (with 1,313,000 m³ in 2021 and 1,336,400 m³ in 2020), and Germany (with 1,102,884 m³ in 2021 and

1,002,347 m³ in 2020). In terms of exports, Croatia demonstrated impressive performance. It was the largest exporter of sawn hardwood among EU countries in 2020, exporting 869,178 m³. This number increased to 1,033,926 m³ in 2021, solidifying Croatia's position as the top exporter among EU countries. Based on the data provided, Croatia demonstrates a robust presence in the sawn hardwood market within the EU.

Klarić, Pirc Barčić and Sertić Basarac (2023) employed the system Generalized Method of Moments (GMM) model to estimate the impact of wood certification on wood exports in Croatia. Wood certification, number of FSC certificates, demonstrated a significant positive influence on wood exports from Croatia. These findings support the idea that sustainable forest management practices contribute to increased wood product exports. Economic factors, such as Gross Domestic Product (GDP) and Gross Domestic Product per capita (GDP per capita), were found to be crucial in driving wood exports. An increase in GDP and GDP per capita positively impacted wood exports, emphasizing the importance of economic prosperity in promoting trade in wood products. The value of production was identified as a significant driver of wood product exports. Higher production value was associated with increased wood exports, highlighting the importance of production capacity and efficiency in driving the export of wood products from Croatia. Overall, this research sheds light on the significance of the wood sector in the European economy and highlights the positive influence of FSC certification on wood product exports from Croatia. The results provide valuable insights for policymakers and stakeholders in the forestry sector, offering opportunities for promoting sustainability and trade in wood products.

The aim of this paper is to analyze changes in Croatian wood products market in response to sustainable development incentives based on production, export and consumption information.

2. MATHERIALS AND METHODS

The research included the analysis of the production, export and consumption of primary wood products.

We used the data obtained from the Croatian Bureau of Statistics (CBS). Production of wood products data were categorized based on the National classification of activities (NKD 2007) using Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (NACE division C 16).

Wood products export data were categorized based on the Customs Tariff Document and area 44 - *Wood and wood products* was used.

The consumption of wood and wood products has been calculated on the basis of the so-called apparent consumption using the following equitation: Consumption = Production – Export + Import.

Analyzed products were: roundwood, fuelwood, industrial wood, sawn wood, wood-based panels and paper and paper boards. Production, export and consumption quantities were selected for three years: 2014 – the first year after Croatia jointed to EU, 2017, and 2020 – the year during a first year of Covid-19. The obtained values are expressed in cubic meters.

3. RESULTS

It is crucial that we optimize use when building a sustainable and climate-neutral economy wood in accordance with the cascade principle, primarily with the help of market incentives. It means that you would wood should be used as much as possible for long-lasting materials and products in order to replace them their high-carbon equivalents and those based on fossil fuels, for example in buildings and furniture, considering that not all wood is suitable for that purpose. The LULUCF regulation stipulates that sinks/emissions in accounting categories of land are determined, among others, in wood products. for this reason, it is very important to monitor the values of production, export and consumption of wood products. Croatia has been monitoring data on production volumes since 1991.

As seen in Figures 1, 2, and 3 the results of three selected years annual round wood production were between 5,2 and 5,9 million m^3; fuel wood production wood was between 1,8 and 2,3 million m^3, while industrial wood production was between 3,0 and 3,6 million m^3. Industrial round wood export values were lower than fuelwood exports in all observed years. Industrial round wood consumption was almost equal to industrial round wood production values.

Production of sawn wood, as sheen in Figure 4, was between 1.4 and 1.7 million m3. What stands out is that production was almost equal to exports. What stands out in Figure 4 as illogical is the consumption of sawn timber in 2014, which was higher than production.

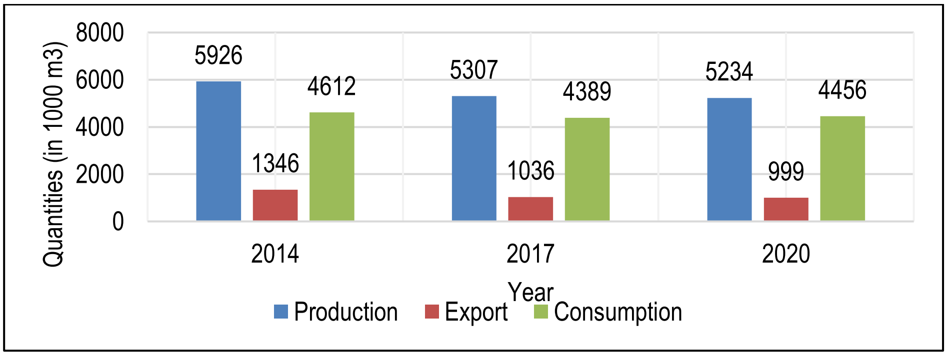

Figure 1. Round wood – production, export and consumption (in 1000m^3)

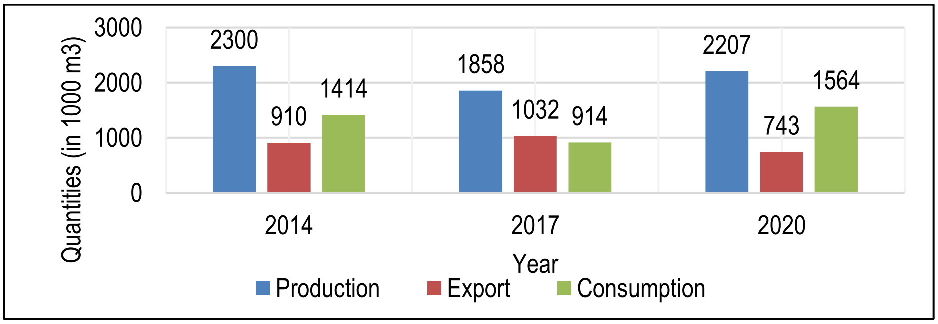

Figure 2. Fuel wood – production, export and consumption (in 1000m^3)

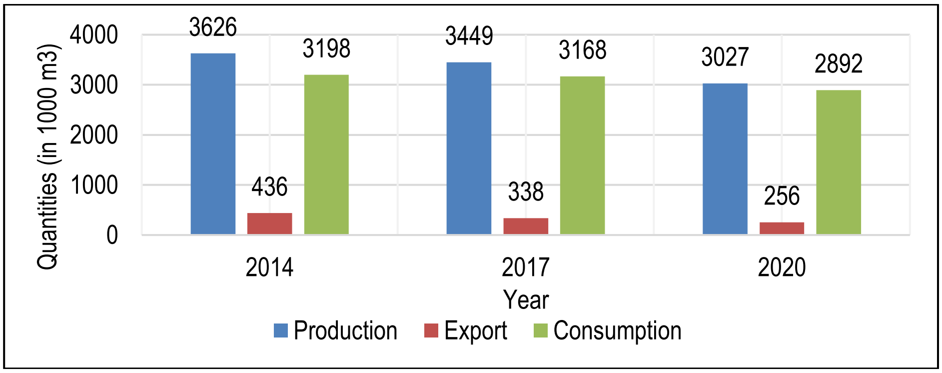

Figure 3. Industrial roundwood – production, export and consumption (in 1000m^3)

In the observed years, the consumption of wood-based panels increased, from 219 thousand m3 in 2014 to 370 thousand m3 in 2020. Export values of wood-base panels were higher in comparison to production values (Figure 5). Tis points to the conclusion that the production of wood-based panel furniture has increased in Croatia mostly including wood-based panels from foreign countries.

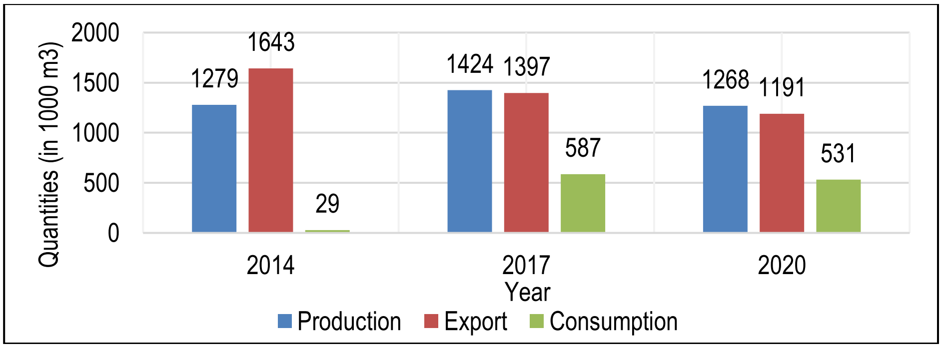

Figure 4. Sawnwood – production, export and consumption (in 1000m^3)

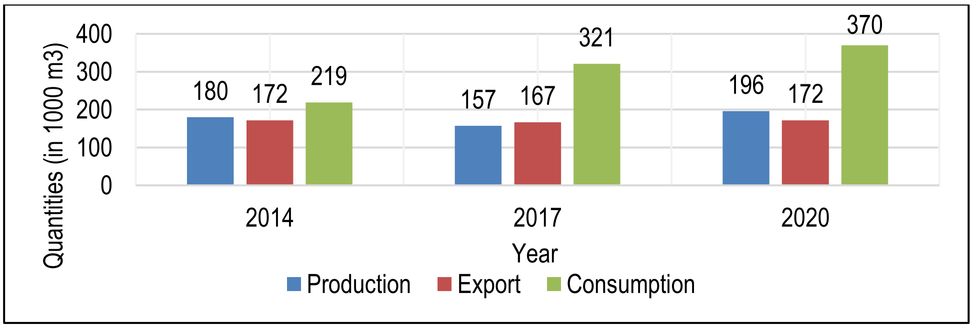

Figure 5. Wood-based panels – production, export and consumption (in 1000m^3)

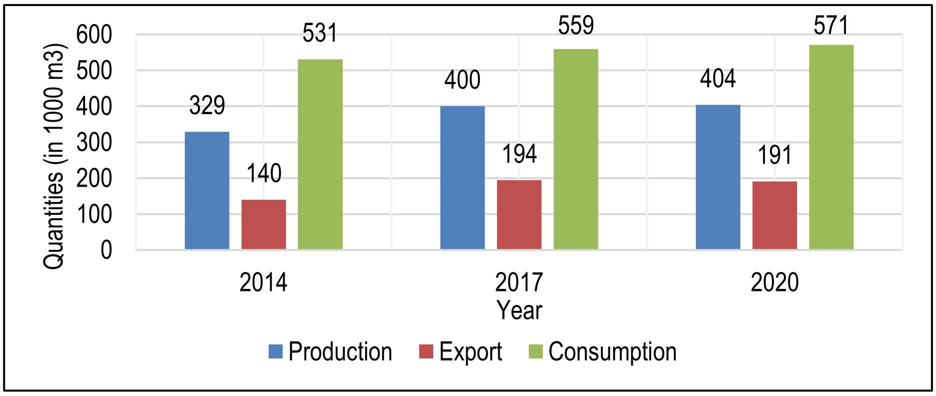

Figure 6. Paper and paperboards – production, export and consumption (in 1000m^3)

Consumption of paper and paperboards, as seen in Figure 6, was between 531 thousand m3 and 571 thousand m3. Consumption values were higher between 30 to 40% in comparison to production values (38% in 2014; 28% in 2017; and 29% in 2020).

Overall, the results show that the Croatian wood industry does not use its primary wood products in accordance with the cascade principles. It turns out that it exports sawn timber, which should be used for the production of Croatian high added value wooden products. On the other hand, the results showed that Croatian manufacturers of wood products use wood-based panels more.

4. CONCLUSIONS

At the Croatian level, there are currently no developed models that could be used to predict the use of wood and wood products in the coming period - 2020, 2030, 2050). Additionally, there are no models that serve the needs of forecasting certain components important for projections of the use of wood products (e.g. there is no model that would predict the total quantities of import and export of wood products in the Republic of Croatia, a model that would predict the economic aspects related to wood products such as the price of these products in the future, etc.). Additionally, this paper points to a conclusion that better and concise understanding about the importance and the role of Croatian wood products industry is necessary in order to present wood industry to sustainable development issues.

REFERENCES

1. Epede, M. B.; Wang, D. (2022): *Competitiveness and upgrading in global value chains: A multiple-country analysis of the wooden furniture industry*. Forest Policy and Economics, 140, 102737.

2. European Organization of the Sawmill Industry (2023): *Annual Report of the European Sawmill Industry 2022-2023*. https://eos-oes.eu/wp-content/uploads/2023/06/eos-annual-report-20222023.pdf (accessed 2.3.2024)
3. Eurostat (2022): *Wood products - production and trade.* https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Wood_products_-_production_and_trade (accessed 2.3.2024.)
4. Government of the Republic of Croatia (2007: *Decision on the National Classification of Activities 2007 - NKD 2007.* Decision on the National Classification of Activities 2007 - NKD 2007 (nn.hr) (accessed 15.3.2024.)
5. Klarić, K., Pirc Barčić, A., Basarac Sertić, M. (2023): *Assessing the role of forest certification and macroeconomic indicators on Croatian wood exports to the EU: A panel data approach*. *Forests*, *14*(9), 1908.
6. Ministry of Agriculture (2016): Forest management Plan 2016 -2025. https://poljoprivreda.gov.hr/UserDocsImages/dokumenti/sume/sumarstvo/procjena_utjecaja_2016-2025/Nacrt_SGOP-a_RH.pdf (accessed 7.3.2024.)

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ANALYSIS OF IKEA'S EXPERIENCE IN GAMIFICATION IN FURNITURE TRADE ONLINE AND OFFLINE IN BULGARIA

Neviana Krasteva

Abstract: The study is dedicated to the strategy and practice of one of the world leaders in furniture trade - IKEA, Sweden on the Bulgarian market. The research examines the application experience of various gamification tools implemented by IKEA online and offline. Yu Kai Chou's octalysis in combination with consumer behavior psychology models was used as the basis of the research design and analysis of results. A survey is being conducted among buyers in Bulgaria to track the impact of applied online and offline gamification mechanisms in the sale of furniture to increase the propensity to purchase. The suggestions and the conclusion are important for getting to know the impact mechanisms of the gamification tools and the expansion of their action in different areas of business in a specific country - Bulgaria.
Keywords: IKEA, Gamification, Bulgaria

1. INTRODUCTION

Gamification enhances retail by integrating gaming elements into shopping experiences, boosting engagement and sales. Through strategies like loyalty programs with points, challenges, and rewards, retailers create emotional connections with customers, encouraging active participation and social sharing. However, challenges include balancing entertainment with value and addressing ethical concerns. Successful implementation requires aligning gamified strategies with audience preferences.

IKEA's Global Retail Approach - the company stands out internationally for its unique strategies: Affordable Quality - they offer high-quality furniture at affordable prices by optimizing production and logistics; Self-Assembly Concept - known for self-assembly furniture, IKEA reduces costs and promotes sustainability; Sustainability Focus - the company prioritizes ecological practices, from material selection to recycling; Global Presence, Local Adaptation - With stores worldwide, IKEA tailors products to local markets; Customer Experience Innovations - IKEA invests in technologies like virtual reality for enhanced shopping experiences; Social Responsibility - IKEA supports social initiatives and community development projects; Overall, IKEA leads the industry with its focus on sustainability, affordability, quality, local adaptation, and social responsibility.

2. LITERATURE REVIEW

Studying the theoretical frameworks of gamification and consumer behavior is crucial for understanding how gaming elements influence consumer actions and decisions. Several key theoretical approaches shed light on this interaction:

2.1. Gamification Theoretical Frameworks

The self-Determination theory (SDT) is focuses on competence, autonomy, and relatedness as key psychological needs. Gamification satisfies these needs through feedback, autonomy, and social interactions (Deci & Ryan, 2015). The flow theory describes a state of complete absorption in an activity. Gamification creates a "flow" state through tailored challenges, enhancing engagement and satisfaction (Biasutti, 2011). The game theory analyzes strategic interactions in gaming environments. Gamification utilizes game theory principles to create competitive environments (Game Theory, Stanford Encyclopedia of Philosophy, 2023). The Octalysis frame explores eight core drives motivating behavior. These include Epic Meaning & Calling, Social Influence & Relatedness, and Accomplishment & Achievement (Chou & Chou, 2023).

2.2. Consumer Behaviour Theoretical Frameworks

The theory of Planned Behavior (TPB) predicts behavior based on intention. Gamification influences attitudes, subjective norms, and perceived control, leading to behavioral changes (Ajzen, 1991). The social cognitive theory (SCT) emphasizes observation and modeling in learning. Gamification facilitates learning through observation of others' actions (The Social Cognitive Theory, n.d.). The elaboration likelihood model (ELM) examines central and peripheral routes of persuasion. Gamification influences consumer beliefs and attitudes through both routes (Schunk, 1989). Adaptation to specific audiences and contexts maximizes the potential of these strategies (Ajzen, 1991; Deci & Ryan, 2015; Schunk, 1989).

2.3. IKEA's Global and Local Gamification Strategies

Globally, IKEA employs innovative virtual planning tools, mobile applications, and loyalty programs to engage customers - virtual planning tools allow customers to visualize home interiors with IKEA products before purchase; Mobile apps educate customers about sustainable consumption through challenges and rewards; Loyalty programs like IKEA Family offer points and rewards for repeat purchases (IKEA Kreativ - Home Design App for Inspired Living Spaces, n.d.; Arun, 2023; Parker, 2024). Locally, IKEA tailors gamification strategies to meet market-specific needs: Events in stores feature gaming elements like QR code scanning and design competitions, customized for local holidays and themes; Feedback platforms encourage customer engagement with gamified features such as points and rewards for active participation. By blending global objectives with local adaptation, IKEA enhances customer engagement and fosters long-term relationships across diverse markets. Gamification serves as a key tool in engaging, educating, and entertaining customers, reinforcing the bond between consumers and the brand.

3. METHODOLOGY

The survey methodology for analyzing gamification's impact on purchasing behavior at IKEA in Bulgaria includes demographic information and shopping habits. Questions cover gender, age, education level, and IKEA shopping frequency and preferences. This data helps identify trends among different demographic groups. Specifically the gender - analyzes potential shopping behavior differences between men and women; Age groups - identifies preferences and habits specific to each age group; Education level: Examines the relationship between education and consumer behavior; Shopping habits: Explores frequency of IKEA visits, preferred products, and shopping platform (online vs. in-store).

The survey also assesses perceptions of gamification at IKEA, aligned with Yu-Kai Chou's Octalysis framework, to understand its impact on the shopping experience.[1]

4. RESULTS

The study results reveal participation from 56 men and 38 women, with an even age distribution ranging from 18 to 55 years. Predominantly, participants hold a higher education degree (77%), followed by those with secondary education (18%). The data were analyzed using descriptive statistical tools, highlighting various demographic data and shopping habits at IKEA. A correlation analysis uncovered a weak positive correlation (0.148443) between age and the frequency of visits to IKEA. The chi-square test found no significant relationship (p-value = 0.360) between gender and education. Further analysis is needed to identify specific trends in consumer behavior and perceptions of gamification at IKEA. Multivariate analysis with PCA (Figure 1) shows relationships between demographic and behavioral characteristics. Dimension reduction to two principal components allows visualization of the complex data structure. The principal components (PC1 and PC2) are linear combinations of original variables, capturing the maximum data variation. PC1 reflects factors like age, gender, and education, affecting respondent differences. PC2 represents attitudes towards gamification, differentiating respondents in a manner distinct from PC1.

Figure 1 illustrates respondent distribution based on their answers and demographic characteristics, using the two principal components. PCA helps identify potential patterns and groups within the data, aiding in the development of targeted marketing and gamification strategies tailored to specific consumer segments. Analysis of shopping frequency (question 4), satisfaction with purchasing methods, and awareness of gamification elements (question 5) from the survey reveal various shopping habits, satisfaction levels, and awareness among respondents. A majority of consumers (82%) rated their in-store shopping activity as low (question 4). However, these consumers recognized and engaged with the application of gamification in the store (question 7) through indirect means, as seen from the data on the use of gamified tools (question 8). This information provides insights for IKEA to improve services and communication regarding gamification elements (question 9), ultimately enhancing engagement (question 10) and customer satisfaction (question 13), showing a positive attitude towards gamification (question 11).

The evaluation of the impact of gamified tools (question 17) on shopping, purchasing decisions, and satisfaction suggests these elements enrich the IKEA shopping experience, offering interactive ways to explore products and plan interiors. The sample includes economically active consumers (75% between 26 and 55 years old), who preferred the "Scandinavian style," influenced by the Swedish chain, despite the relatively even distribution of opinions on the impact of identified psychological practices by the chain (question 14). Brand attachment and gamification (question 16) are factors that encourage spending more time with

[1] Upon request, we can provide the specific survey data.

it, and gamified methods help in decision-making and enhance overall satisfaction, strengthening brand loyalty and generating positive word-of-mouth.

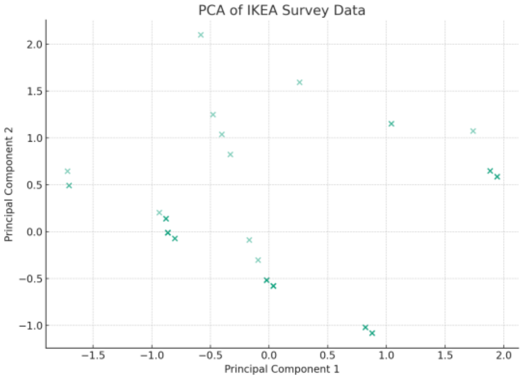

Figure 1. PCA of IKEA Survey Data

The continuous development and adaptation of gamification strategies (recognized by 48% of respondents) based on feedback (question 7) are crucial for IKEA to maximize their effectiveness and respond to changing consumer preferences in a distinctive brand context.

Analyzing perceptions of online (rated in question 11 with an average score of 3.44 on a 5-point scale) and offline gamification methods (rated in question 12 with a score of 3.35 or neutral) reveals differences in user interaction and perception but offers the brand opportunities for omnichannel campaigns. Implementing gamification in both contexts (integration rated in question 13 with a score of 3.44 on a 5-point scale) presents unique opportunities and challenges for brands, enhancing engagement and loyalty. Investigating the impact of integration on shopping is crucial for maximizing effectiveness. An interesting argument is whether gamification influences consumers' propensity to purchase the company's products (question 17). The even distribution of opinions shows that recognition of gamification as a factor is multifaceted.

Combining online and offline gamification methods is seen as a holistic approach that improves transitions between shopping, enhancing satisfaction and engagement, as evident from the data on key factors influencing furniture purchase decisions, revealed by shared opinions on the future of gamification in furniture retail (question 19). Integration allows engagement at touchpoints, encouraging repeat purchases and positive word-of-mouth. It also enables brands to create a cohesive, enriched experience reflecting their values and message across channels, known from shared opinions in question 18.

5. DISCUSSION

Analyzing perceptions of online and offline gamification sheds light on how these methods impact the retail customer experience. IKEA utilizes gamification both online and offline to engage customers innovatively. Integration of these approaches enhances the customer experience.

Analyzing survey data through the Octalysis framework provides valuable insights into gamification's influence on consumer behavior and engagement. (Table 1)

Table 1 Impact of Gamification on Purchase Decisions and Engagement- IKEA Case

	Octalysis framework	IKEA implementation
1	Epic Meaning & Calling	IKEA can create engaging stories or missions to make shopping feel significant, boosting engagement and purchase decisions.
	Social Influence & Relatedness	IKEA platforms can foster social interaction through design sharing or group challenges, promoting inclusion and engagement
3	Development & Accomplishment	reward systems and loyalty points motivate customers, enhancing satisfaction and repeat purchases
4	Empowerment of Creativity & Feedback	interior planning tools empower creativity and provide feedback, increasing engagement and satisfaction
5	Ownership & Possession	loyalty programs allow customers to collect points, fostering a sense of ownership and fulfillment
6	Loss & Avoidance	gamified elements motivate action to prevent loss of rewards, maintaining engagement
7	Scarcity & Impatience	limited-time offers create urgency, prompting quick action
8	Unpredictability & Curiosity	random rewards sustain interest and encourage return visits

We see potential in further research into the relationship between consumer behavior management tools and Yu Kai Chou's postulates, as an extension of the findings noted in Table 2

Gamification's Impact on Purchase Decisions and Engagement in Bulgaria

Gamified campaigns strengthen brand-consumer connections in Bulgaria's evolving digital landscape, improving customer experience and loyalty. Local adaptation of gamification strategies is essential to resonate with Bulgarian consumers' preferences and cultural nuances.

Analyzing survey results with the Octalysis framework can pinpoint effective gamification aspects for the Bulgarian market. Integrating online and offline gamification elements is crucial for enhancing customer engagement and sales, tailored to Bulgarian consumers' preferences and motivations. The lesson is clear - successful gamification requires understanding consumer needs and preferences, tailored strategies, and continuous innovation.

6. CONCLUSION

Integrating online and offline gamification at IKEA can significantly enhance customer engagement and satisfaction. By blending entertainment and interactivity, IKEA creates a memorable shopping experience, attracting and retaining customers. Adapting gamification strategies to evolving consumer preferences is crucial for success. Gamification in Bulgaria transforms traditional shopping into an interactive and enjoyable experience, boosting customer satisfaction and loyalty. Tailoring gamification to local cultural and consumer characteristics is essential for maximum impact. In summary, gamification at IKEA in Bulgaria enriches the shopping experience, influences purchase decisions positively, and boosts overall satisfaction and engagement. Continuous adaptation and integration of gamification methods ensure sustained success and customer loyalty.

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REFERENCES

1. Ajzen, I. (1991). The theory of planned behaviour. Organizational Behaviour and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-t
2. Arun, R. (2023, November 22). IKEA Marketing Strategy 2024: A Case Study. Simplilearn.com. https://www.simplilearn.com/tutorials/marketing-case-studies-tutorial/ikea-marketing-strategy-case-study
3. Biasutti, M. (2011). Flow and optimal experience. In Elsevier eBooks (pp. 522–528). https://doi.org/10.1016/b978-0-12-375038-9.00099-6
4. Chou, Y., & Chou, Y. (2023, September 17). The Octalysis Framework for Gamification & Behavioural Design. Yu-kai Chou - Learn how to use Gamification to make a positive impact on your work and life. https://yukaichou.com/gamification-examples/octalysis-complete-gamification-framework/
5. Deci, E. L., & Ryan, R. M. (2015). Self-Determination Theory. In Elsevier eBooks (pp. 486–491). https://doi.org/10.1016/b978-0-08-097086-8.26036-4
6. Game Theory (Stanford Encyclopaedia of Philosophy). (2023, September 3). https://plato.stanford.edu/entries/game-theory/
7. IKEA Kreativ - Home design app for inspired living spaces. (n.d.). https://www.ikea.com/us/en/home-design
8. Parker, A. (2024, January 29). How IKEA Family strengthens customer bonds - Adom Parker - medium. Medium. https://medium.com/@loyaltyconsulting0400/how-ikea-family-strengthens-customer-bonds-29849bff56ad
9. Schunk, D. H. (1989). Social Cognitive Theory and Self-Regulated Learning. In Springer series in cognitive development (pp. 83–110). https://doi.org/10.1007/978-1-4612-3618-4_4
10. The Social Cognitive Theory. (n.d.). sphweb.bumc.bu.edu. Retrieved March 8, 2024, from https://sphweb.bumc.bu.edu/otlt/mph-modules/sb/behavioralchangetheories/behavioralchangetheories5.html

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TRADE IN SELECTED TYPE OF WOOD

Eva Habiňáková, Andrea Tománková, Renata Nováková

Abstract: Trade, trading and market represent a broad term, as this category includes areas related not only to trade and sales, but also marketing distribution channels, consumer markets, psychology, sociology, up to logistics, distribution, transport, transit and forwarding. In the article, the authors define general trading terms as well as terms from the wood trade and market.
Furthermore, they deal with the characteristics and analysis of trade with the protected tropical wood species Dalbergia nigra within the EU and the world, its import, export and international trade. In 1998, the species Dalbergia nigra was included in the Red List of the World Conservation Union as an endangered species. This wood has fascinated people for hundreds of years and, despite its high price, it manages to find its clientele.
The market (and not only with wood) also has certain rules that are set by owners and consumers alike. We are talking about two important business methods that are the driving force of the entire market, and that is supply and demand. The main factors affecting the trade and market of wood raw materials are laws and legislation, as well as the possibility of using clear technical conditions in wood processing.
Keywords: trade, international trade, timber trade, Dalbergia nigra

1. TRADE AND TIMBER TRADE

Trade is a broad term. This category includes areas related to trade and sales from retail and wholesale to services, international trade, marketing distribution channels, consumer and government markets, psychology, sociology, to logistics, distribution, transit, transportation and forwarding.

Trade can be defined from several points of view. From a sociological point of view, it is the activity of people. From the point of view of economics, trade is understood as a specific economic activity that involves the exchange of products on the market through monetary means (Paluš, 2004).

Trade is the fastest growing industry. The degree of development of the social division of labour is a factor on which the dynamics of trade development depends. In terms of territorial implementation, trade is divided into: domestic, foreign, world, international.

Domestic trading provides needs within the state. We also call it internal, because it does not cross the borders of one or another country, because its products are either produced in the country and sold there, or bought on the domestic market.

Foreign trade ensures the circulation of goods of a given country, which also operates in areas beyond the state's borders and thus conducts international trade in goods based on the import and export. It represents that part of the circulation of goods and services that crosses state borders and connects the national economy with the world economy. Foreign trade thus ensures the import of goods that cannot be obtained on the domestic market. It is also significant that within the social division of labour it is carried out with conditions that represent the most advantageous variant within the countries that specialize in the given products. We consider the advantages of foreign trade to be the enlargement of the domestic market, the expansion of the assortment, the comparison of goods from several countries that cannot be produced in the given country, and it also enables specialization in the production of those goods for which it has the best conditions. On the contrary, we consider dependence on markets in a certain area and preventing the development of domestic manufacturing industries by importing goods from other countries and competing with domestic products as disadvantages.

World trade, which ensures social-production relations, also has an international form. The international division of labour is also the most important for international trade, which represents the sum of trades that are located beyond the borders of all countries that are involved in the international division of labour. The essence of foreign trade is: the export of products that are produced in a given country or produced in sufficient amount, the import of products that are not produced in a given country or there is a shortage of them.

International trade in the world is slowing down rapidly. It already started the decline in the last quarter of 2022. International trade continues to be pushed back by high interest rates and inflation, which cause people and businesses to spend less. However, that is starting to change. Before covid, everyone was looking for a way to produce their goods as cheaply as possible. It was mostly found in China. However, with covid and then with the war in Ukraine, businesses started looking for alternative locations. Companies are looking for new locations for their production, as global supply chains have been disrupted during the covid pandemic, slowing down production and long-distance transport, which has become many times more expensive. At the same time, after decades of deepening globalization, individual countries or regions tend to control industrial production on their territory more and increase their self-sufficiency.

There is also another division of trade: retail, wholesale, intermediaries. We further define the divisions of trade according to the type of ownership, legality, place of operation (Paluš, 2004).

Timber trade is the most widespread form of trade in every country. The domestic market consists of the import and export of wood to countries where there is a need for this renewable resource and where it is necessary to meet the needs of the population. The business is based on sales and purchases within the domestic, foreign and international territory. The market requires certain rules according to which trades are concluded. We are talking about standards, classifications of wood, which are important for conducting business. We know different methods of quantitative classification of wood and its products based on general conditions (characteristics of wood, volume, type of wood, etc.) (Paluš, 2004). The importance of wood is currently growing, and the competition on the wood market is also growing with it. Wood is used in various spheres of economy, construction, industrial production, agriculture, transport and it is part of everyday human needs (Paluš, 2010). The timber trade is governed by certain rules that are national and international in nature. The subject of wood trading are the most common assortments of raw wood, which are divided into quality classes. The wood trade is mainly influenced by market demand and supply. Demand for wood is characterized as derived demand, i.e. if the demand for final products grows, so does the demand for raw wood. There is also a mutual relationship between supply and demand. The supply is influenced by the size of the stock from which it is logged and which creates the potential of the given country, logging possibilities and also the emphasis placed on sustainable forest management (Paluš, 2010).

In 2020, the trade in wood began to decline in general due to the pandemic, which affected state and non-state enterprises and wood processors. Transit between states was also restricted due to the coronavirus. This situation enhanced the economic crisis because several negative factors came together. It had a negative impact mainly in the field of forestry and trade, as well as in the wood industry. Since 2021, the situation in the area of timber trading has improved again.

2. DESCRIPTION AND CHARACTERISTICS OF DALBERGIA NIGRA

Dalbergia nigra occurs in South America and Eastern Brazil. It is a slow-growing tree, reaching a height of 12-20 meters. The shape of the trunk is irregular (rarely cylindrical), its bark is brown and slightly cracked (Wagnerführ, 2007). Dalbergia nigra produces very hard and heavy wood. The sapwood is narrow, white and the core is darker, it is characteristically variegated, from brick red to various shades of brown (dark brown to chocolate brown with purple hues to almost black). The wood, which contains a grainy texture of black coloring called "spiderwebbing", is extremely popular. The venation arises from strips of parenchymal cells with black nuclear content. Particularly popular and the most expensive types are those on which there are nice bright spots next to dark stripes (with a strong color contrast). Landscape, climate and soil have a significant influence on the coloration of rosewood (Jirout, 1928; Wagnerführ, 2007).

Figure 1. Habitus Dalbergia nigra

Figure 2. Odd-pinnate leaves, capsules, flowers

Dalbergia wood is in great demand, it was first used hundreds of years ago. Between 1811 and 1820, Dalbergia nigra became popular in the production of high-quality furniture, especially in the United Kingdom. The species Dalbergia nigra was used in various musical instruments, for decorative parts, in the production of knife handles. Rio rosewood remains highly prized by guitar makers who consider it one of the best sounding woods, specifically when making backs and sides. Already in the past, it was used in the manufacture of instruments, in the Renaissance and Baroque eras, when it was used for the backs (ribs) of various parts of stringed musical instruments. It was also used in the production of wind instruments, such as flutes (Wagnerführ, 2007; Jirout, 1928).


Figure 3. Body of the guitar


Figure 4. Dining table

Due to the high price, the string instrument community is looking for the "new Brazilian rosewood". Alternatives come in the use of hard, exotic woods such as African blackwood Dalbergia melanoxylon, Wenge, Congolese rosewood Milletti alaurentii, Madagascar rosewood Dalbergia baronii and Indian rosewood Dalbergia latifolia or Machaerium scleroxylon (none of these woods are subject to CITES control) (Trade in Dalbergia nigra and the European Union, 2012).

3. INTERNATONAL TRADE IN DALBERGIA NIGRA SPECIES

International trade in general is a very old form of international economic cooperation. Historically, the oldest form of external economic relations is the international trade, which is still an important part of them today. Today, international trade is mainly associated with the phenomenon of globalization and the growing importance of international relations (Allen, 2009).

The more economically advanced a country is, the more likely it is to engage in the international division of labour through international trade. Involvement of the country in the international division of labour expands its export and import possibilities (Euroeconomist, 2018).

Since the inclusion of the Dalbergia nigra species in the CITES convention in 1992, international trade has been on a downward trend. Since 1992, several different units have been used to trade Dalbergia nigra. Volumes reported in cm2, mm2, pairs, sets and consignments were not taken into consideration and they were believed to represent a negligible proportion of total trade records (less than 2.5% of total trade records). The analysis focused only on deliveries reported in kg or m3 and on records where units were not specified. The volume in unspecified units represented more than 85% of the total amount, on the basis of which a realistic quantification of the trade was not possible. However, based on the information available, it was possible to identify the countries involved in the Dalbergia nigra trade and reveal general trade trends.

Since the inclusion of D. nigra in Appendix I of the CITES Convention, the trade has been transformed into products such as veneer, furniture and carving material, and the trade has been significantly reduced. Diversification can be explained by the growing shortage of wood raw materials. The key importers were Japan, the USA, the EU and Canada. After Spain, the Netherlands was the second most important importer within the European Union, followed by the United Kingdom, Italy and Germany (Trade in Dalbergia nigra and the European Union, 2012). Since the inclusion of Dalbergia nigra in Appendix I of the CITES convention, the trade has been significantly reduced.

Regarding imports of D. nigra specimens reported as "pre-convention" (before inclusion in the CITES Convention), trade data show significant discrepancies in the volume reported by exporting and importing countries. Exporters reported more than double the quantities reported by importers. At the proposal of the German CITES Management Authority, a review of export documents obtained from EU trading partners (such as the US Fish and Wildlife Service) was initiated to quantify the trade problem. Based on CITES regulations, the exporter is obliged to archive transport documents for a period of 5 years. The EU plays a key role in the international trade of D. nigra and is an important destination for exports from countries such as the USA. The re-export of D. nigra from the EU during 1992–2010 was considerably higher than the imported quantity. This may indicate a significant amount of "pre-Convention" D. nigra material in stocks across the EU that was imported prior to 1992. This conclusion is supported by reports from CITES management bodies. It is also possible that part of the deliveries enter the EU illegally or undeclared. Trade data indicate that some Member States may apply a different interpretation of CITES provisions, which was confirmed by at least one member state. The importance of the US as a reverse exporter emphasizes the importance of close involvement of US authorities in all steps taken to address issues related to trade in D. nigra (Trade in Dalbergia nigra and the European Union, 2012).

The illegal trade in D. nigra is not well documented and its current extent is largely unknown. In general, there is a high level of awareness, especially among string instrument producers. According to several manufacturers, the trade is carried out illegally. Within this framework, international cooperation focuses on:

• documenting the illegal logging of D. nigra wood, with the aim that the European Commission and EU member states communicate with Brazil and document the current state of the issue through CITES channels,

• The European Commission and CITES authorities in the EU were advised to work closely with the EU's key trading partners, especially the US,

• The European Commission and EU Member States should consider submitting key findings to relevant international forums such as CITES, the World Customs Organization (WCO) and Regional Information Liaison Offices (RILOs) in order to promote international cooperation (Trade in Dalbergia nigra and the European Union , 2012).

In 1998, the species Dalbergia nigra was included in the Red List of the World Conservation Union (IUCN) as a "threatened species". The attrition rate was extremely high in the past. It was primarily the result of excessive logging and reckless devastation of the forest habitat. Low densities were recorded as early as the 1920s, and the species became increasingly rare by the 1990s. The recovery rate is very low due to the mentioned unregulated logging and frequent attack by biological pests. According to the CITES report, illegal logging of D. nigra remains a problem to this day.

In general, it should be remembered that wood is a renewable source of raw material, which has a wide range of uses. In recent years, the timber trade has been affected by various negative factors, such as the global economic crisis, climate change, bark beetles attacking mainly conifers, but also political and lobbying pressures.

REFERENCES

1. ALLEN, L.: *The Encyclopedia of Money*. California : ABC-CLIO, LLC, 2009. ISBN 978-1-59884-252-4.
2. JIROUT, F.: *Dřevo v přírode a řemeslech v živnosti a průmyslu vůbec*. 2. vydanie. Praha, 1928.
3. PALUŠ, H.: *Obchod s drevom a výrobkami z dreva*. Zvolen 2004. 112s. ISBN 80-228-1378-8.
4. PALUŠ, H.: *Obchod s drevom a výrobkami z dreva*. 2. Vyd. Zvolen : TU Zvolen, 2010. 111 s. ISBN 978-80-228-2092-9.
5. WAGENFÜHR, R.: *Holzatlas.* 6. vydanie. Leipzig: Fachbuchverlag, 2007. 816 s. ISBN 3-446-40649-2.
6. WAGENFÜHR, R.: *Dřevo – obrazový lexikon*. Praha: Grada Publishing a.s., 2002. ISBN 80-247–0346-7.
7. WGBL. 2020. *Best ways to promote an Educational Institute*. [online]. [cit. 16.2.2024]. Available at: <https://wgbl.co/blog/educational-institute-promotion>.
8. <https://www.euroekonom.sk/obchod/medzinarodny-obchod/> [cit. 4.3.2024].
9. <https://index.sme.sk/c/23234526/mapa-svetoveho-obchodu-sa-meni.htm>l [cit. 4.3.2023].

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THREATS TO SUSTAINABILITY GOALS – ILLICIT TRADE PRACTICES IN WOOD-BASED SECTOR AND WOOD PRODUCT QUALITY INFORMATION

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Abstract: Illicit timber and wood trade are an unwelcome practice. For example, a clear-cutting of an area of forest equivalent to a football field happens every two seconds worldwide. The illicit trade of timber depletes origin countries' natural resources and has direct impact on sustainability and climate change. At the same time, according to Europol illicit timber trade is one of the most financially rewarding transnational criminal activities, generating an estimated USD 7 billion. The new EU Deforestation Regulation came into force in June 2023 (it will replace the European Union Timber Regulation – EUTR), will start to be applied from the end of 2024. Namely, illicit trade in wood and wood products, improperly and incorrectly defined and highlighted declarations of wood products represent a significant problem. Given that the changes in wood supply and trade raise crucial questions for the implementation of the various policy measures, and for their effectiveness in achieving the objectives of tackling illicit trade and establishing a sustainable wood-based sector. In that context, the aim of this paper is to analyze practices, challenges, and consequences of illicit trade practices within wood-based sector and its products at EU and global level. Additional aim is the short overview data regarding quantity, transparency and accuracy information on wood products that can be bought at selling places in Croatia.

Keywords: wood industry; illicit trade; product quality information; sustainability

1. INTRODUCTION

Illicit timber and wood trade is an unwelcome practice. For example, a clear-cutting of an area of forest equivalent to a football field happens every two seconds worldwide. The illicit trade of timber depletes origin countries' natural resources and has direct impact on sustainability and climate change. At the same time, according to Europol illicit timber trade is one of the most financially rewarding transnational criminal activities, generating an estimated USD 7 billion.

There is no standard definition of illicit trade (Shelly, 2020). The World Customs Organization (WCO) has been issuing annual reports on illicit trade since 2012 and it defined illicit trade as the following: Illicit trade involves money, goods or value gained from illegal and otherwise unethical activity. It encompasses a variety of illegal trading activities including human trafficking, environmental crime, illegal trade in natural resources, intellectual property infringements, trade in certain substances that cause health and safety risks, smuggling of excisable goods, trade in illegal drugs and a variety of illicit financial flows. Furthermore, in 2014 the United Nations Security Council brought up a Resolution 2195 particularly focusing on forms of illegal activity and illicit trade. In 2016, the OECD (Organisation for Economic Co-operation and Development) developed its own definition of illicit trade, which is more focused on the consequences of illicit trade, including its impacts on economic stability, social welfare, and public safety. According Andreas (2004) an "Illicit trade" is a term used to describe a number of diverse and invasive practices that characterize our societies, involving illicit flows of goods, money, services, information and people. Namely, illicit trade in wood and wood products, improperly and incorrectly defined and highlighted declarations of wood products represent a significant problem. Given that the changes in wood supply and trade raise crucial questions for the implementation of the various policy measures, and for their effectiveness in achieving the objectives of tackling illicit trade and establishing a sustainable wood-based sector. In that context, the aim of this paper is to analyze practices, challenges, and consequences of illicit trade practices within wood-based sector and its products at EU and global level. Additional aim is the short overview data regarding quantity, transparency and accuracy information on wood products that can be bought at selling places in Croatia.

2. ILLICIT TRADE AND WOOD PRODUCTS

As highlighted by the United Nations Conference on Trade and Development (2020), illicit trade compromises the achievement of the UN Sustainable Development Goals by displacing legitimate economic activity and depriving governments of revenues for investment. Additionally, countries have committed to 'significantly' reducing 'illicit financial flows' (IFFs) by 2030 in accordance with Sustainable Development Goal (SDG). According to OECD illicit trade generates billions of dollars annually for transnational criminal networks. According to the World Economic Forum, illicit trade creates an annual drain of approximately USD 2.2 trillion on the global economy – nearly 3 per cent of total gross domestic product. If illicit trade was a country, its economy would be larger than Brazil's, Italy's or Canada's, and as large as Mexico's and Indonesia's combined (UNCTAD, 2020).

2.1. Illicit trade of wood products

As demand for timber products increases, so does illegal logging, which is a major driver of the deforestation devastating forest-dependent communities, and worsening climate change. In recent years, many conservationists have rightly celebrated the increase in sustainable forestry around the world. However, the global demand for timber products continues to rise, with one report estimating a global market value of nearly $998.47 billion by 2022. Industrial logging is still the primary source of timber and timber-based products and much of this logging is often unsustainable and illegal. Unsustainable and illegal logging in the tropics reduces the financial viability of holding the land as managed forest and thus leaves it more vulnerable to land-clearing for mining and agriculture. It also threatens endangered species like Indonesian orangutans and Siberian tigers – as well as the trees themselves. Rosewood has been called "the ivory of the forest" due to how widely it is trafficked, leaving many of the trees that produce it threatened. Deforestation claims an estimated 10 million hectares each year (FAO 2020). As much as 23% to 30% of hardwood lumber and plywood traded globally could be from illegal logging activities, and illegal timber accounts for over 70% of timber exports in several countries with high-carbon tropical forests like Peru, Bolivia and the Democratic Republic of Congo. As the illegal timber trade continues to grow, so does opportunities for fraud in connection with timber harvesting as well as in the wood products supply chain. Globally, according to Interpol, as much as one-third of wood furniture—our chairs, tables, doors, beds—is built from timber that has been illicitly harvested. Every year, the world loses 10 million hectares of wood, or an area the size of Iceland, due to unlawful logging. Interpol states that the illegal timber industry is worth almost $152 billion annually (Nellemann et al. 2020). Bisschop (2015) noted that Illegal timber trade is the commercial activity of illegally trading timber across one or more state borders without proper papers or authorization and most illegally extracted timber is consumed domestically and never actually enters the international market. Gan et al. (2016) also confirmed that. The large majority of tropical timber is consumed directly on domestic markets; only ten per cent of illegally produced wood products are traded on the international markets. The illegal trade in timber is almost always linked to other criminal offenses, including forgery, mislabeling, tax evasion, corruption, bribery and money laundering and mostly comprises high-value species characterized by a large profit margin. What constitutes illegal activity in the industrial logging sector depends on which local and national laws are applicable. In the tropical countries where the most valuable timber is harvested, local and national laws typically regulate the location, amount and method of harvesting.

2.2. Illicit practices in wood-based sector

Before illegal timber enters the market of consumer countries it passes through a complex global supply chain involving multiple layers and types of markets as well as a wide network of actors, including tree owners, millers, intermediaries, traders and purchasers (Kishor and Lescuyer 2012). Pardo (2021) in his work 'The Vietnamese Furniture Industry: A Trade Discrepancy Analysis' observed import and export flows between EU and Vietnam. He noted that recent changes such as the 2019 Vietnamese Voluntary Partnership Agreement with the European Union may improve the situation, available data shows discrepancies that indicate under-reporting of high-risk timber imports into Vietnam as well as significant differences in the reported values of various furniture exports. These differences cannot be explained by standard variables in import and export costs and can potentially be used to disguise illicit movement of money around the world. However, mismatches between the exporting and the importing reports can also be result of deliberate trade mis-invoicing (UNCTAD 2020), a key method for illegal movements of value across borders, commonly known as illicit financial flows. As one of the biggest players in the timber business, China has also emerged as the primary destination for the illegal timber trade (Carry and Maihold 2022) and as an export-oriented economy, the country now depends on imported timber to produce secondary wood products for export (Zhang and Gan 2007). Perazzoni (2018) noted Illegal logging continues to be a major issue in Brazil, where up to 70 per cent of the total forestry production is believed to be illegal.

3. HOW WE CAN PREVENT ILLICIT TRADE AND INCOMPLETE LABELING TRADE IN WOOD-BASED SECTOR

Many forests suffer from illegal exploitation and poor management. FSC was established as a response to these concerns over global deforestation. The FSC Policy for Association complements the stringent rules FSC already has in place against illegal timber. It strictly forbids organizations associated with FSC to get involved in unacceptable activities that would contradict the core values of FSC. In fact, the first unacceptable activity listed in the Policy for Association is 'Illegal logging or the trade in illegal wood or forest products. Violating this policy can result in the termination of all association with FSC. The EU Timber Regulation is intended to curb the trade in illegally harvested timber. In Germany, about 27,000 companies that import wood or wood products are subjected to the EUTR. In 2018, the Thünen Centre of Competence conducted a survey among German importers on the implementation of the EUTR. It showed that small companies outside the timber sector in particular are often unaware of the EUTR. Calculations by the Thünen Institute show that in 2020 about 87 % of the imported timber volumes into the EU has been covered by the EUTR. Additionally, in 2018, the Thünen Centre of Competence conducted a survey among German importers on the implementation of the EUTR. It showed that small companies outside the timber sector in particular are often unaware of the EUTR. Only 42 % of the 540 market participants surveyed were aware of the EUTR and that the directive also applies to them. However, these companies together import 91 % of all EUTR products (in terms of total value in euros). Additionally, only 42 % of the 540 market participants surveyed were aware of the EUTR and that the directive also applies to them. However, these companies together import 91 % of all EUTR products (in terms of total value in euros). 28 % of operators reported having the mandatory due diligence system in place. The General Product Safety Directive (GPSD) requires importers and manufacturers to ensure that their products, including furniture, are safe to use. Importers and manufacturers are also required to provide a traceability label. Although following harmonised standards is not mandatory, it is a way to ensure that the products are compliant with the requirements of the directive.

Sanco (2006) noted that labelling is an important market tool which should be viewed as an integral part of communication between societal players (business to consumers, directly and via intermediaries, authorities to consumers, etc.).. The benefits of consumer information in general and labelling in particular are clear. For the consumer, it provides the means for the operator to pass on essential information about products (use-by dates, safety warnings, etc.) as well as information which, whilst perhaps not essential, is considered useful (nutrition labelling, recycling details, etc.). As such, the label has the role of allowing the consumer to make an informed choice at the point of sale about whether to purchase a product and, if they do so, to consider how best it should be used.

4. ILLICIT TRADE OF WOOD PRODUCTS AND SUSTAINABILITY

Illegal logging and its associated timber trade have enormous environmental, social and economic implications (Carry and Maihold 2022). Uncontrolled logging is responsible for a host of problems, including biodiversity loss, desertification, and greenhouse gas emissions. And the global demand for wood is only increasing. Carry and Maihold (2022) noted that according to Global Witness (2021) the year 2020 has been declared the deadliest year so far for land and environmental defenders, with more than 220 lethal attacks recorded, many of which were associated with forestry. For an example, until 2010, the Brazilian government had made significant progress in illegal deforestation, with data showing that deforestation rates were down 70 per cent in 2013 compared to the average from 1996 to 2005, while greenhouse gas emissions resulting from deforestation had been cut by almost 70 per cent (Corrêa 2014 published in Carry and Maihold 2022).

5. ILLICIT TRADE AND LABELING OF WOOD PRODUCTS IN CROATIA

Croatian Forests was the first forest management company from the Adriatic-Balkan region to apply for FSC forest management certification. In 2002, after a successful third-party audit, it received the FSC FM certificate, which covered more than 2 million ha of state forest area. Until 2007, Croatian Forests was the only FSC-certified forest management company in the region, making it a pioneer in forest management certification. Also, the fact that Croatian Forests ltd. can market all its products as FSC certified is of great importance for the Croatian wood industry, considering that most of their raw material comes from that source. Wood processors have recognized this opportunity so that there are currently over 300 FSC COC certified companies in Croatia, which have thus gained a great comparative advantage. The existence of the certificate should encourage the export orientation of our wood industry, in such a way as to achieve greater added value to the products. Furthermore, within a Cost Action titled 'Globalization, Illicit Trade, Sustainability and Security ‘and in cooperation with a Department of Wood Science and Technology Biotechnical Faculty University of Ljubljana we developed a questionnaire aiming to analyze a quality, quantity, transparency and accuracy of available information will be investigated. All this will help us to give a present state about the transparency and availability of information which will contribute to better understanding of the level of illicit trade practices regarding wood-based products. The first preliminary results showed that sellers of wood products label their wood products, but not sufficiently detailed and transparent. More detailed analysis will be conducted in the short period of time and comparison with the Slovenian selling places of wood products will be made.

6. SUMMARY

Illicit timber trade includes practices such as logging in protected areas, exceeding permitted harvest quotas, processing logs without the necessary licenses, operating under a license that has been obtained illegally and exporting products without paying export duties. These illicit practices leave large areas deforested, barren or unable to renew harvests for decades. Additionally, illegal logging undermines the important role forests play as “carbon sinks” in climate systems by limiting their potential to absorb carbon dioxide. On the other hand, illicit trade within wood-based product withholds consumers of the relevant information to make choices, based on awareness for sustainable development in harmony with nature, including consumption of rare woods and woods sourced unsustainably. Moreover, illicit timber trade strips the economic livelihood of local communities and responsible companies. The wood-based sector has changed significantly since the turn of the century: the ways in which timber is produced have altered, and patterns of consumption and trade have shifted. During this same period, the policy environment has evolved too. Not only has there been an expand of efforts aimed at tackling illegal logging, wood and wood-based products have also risen up the agenda in international policy processes related to sustainable development and climate change. The changes in timber supply and trade raise crucial questions for the implementation of the various policy measures, and for their effectiveness in achieving the objectives of tackling illicit trade activities and establishing a sustainable wood-based sector.

REFERENCES

1. Andreas, P. (2004): *Illicit international political economy: the clandestine side of globalization*. Review of International Political Economy, 11(3), 641-652.
2. Bisschop, L. (2015): *Governance of the illegal trade in e-waste and tropical timber*. Case studies on transnational environmental crime. Farnham: Ashgate.
3. Carry, I.; Maihold, G. (2022): *Illegal logging, timber laundering and the global illegal timber trade*. In Geopolitics of the Illicit (pp. 275-308). Nomos Verlagsgesellschaft mbH & Co. KG.
4. Furniture Regulations in the European Union: A Complete Guide (compliancegate.com)
5. Gan, J; Cerutti, P.; Masiero, M.; Pettenella, D.; Andrighetto, N.; Dawson, T. (2016): *Quantifying illegal logging and related timber trade*. In: Kleinschmit, D.; Mansourian, S.; Wildburger, C.; Purret, A. (eds.): Illegal logging and related timber trade. Dimensions, drivers, impacts and responses. A global scientific rapid response assessment report. Vienna: IUFRO, pp. 38–59.
6. Nellemann, C.; Henriksen, R.; Pravettoni, R.; Jesperson, S. (2020): *Forestry Crimes and Our Planet.* In: Nikolakis, William/Innes, John L. (eds.): The wicked problem of forest policy. A multidisciplinary approach to sustainability in forest landscapes. Cambridge: Cambridge University Press, pp. 197–230.
7. Organisation for Economic Co-operation and Development (2018): *Governance Frameworks to Counter Illicit Trade.* Paris: OECD Publishing. http://www.oecd.org/corruption-integrity/reports/governance-frameworks-to-counter-illicit-trade 9789264291652-en.html.accesed (3.3.2024.)
8. Pardo, C. (2021). The Vietnamese furniture industry: a trade discrepancy analysis. https://traccc.gmu.edu/wp-content/uploads/2022/02/The-Vietnamese-Furniture-Industry-A-Trade-Discrepancy-Analysis.pdf (accessed 15.3.2024.)
9. Perazzoni, F. (2018): *Amazonia, organized crime and illegal deforestation. Best practices for the protection of the Brazilian Amazon*. In: Ungar, Mark (ed.): The 21st century fight for the Amazon. Environmental enforcement in the world's biggest rainforest. Cham: Palgrave Macmillan, pp. 21–55.
10. Sanco, D. G. (2006). Labelling: competitiveness, consumer information and better regulation for the EU. Consultative Document. https://food.ec.europa.eu/system/files/2016-10/labelling-nutrition_better-reg_competitiveness-consumer-info_en.pdf (accessed 18.3.2024)
11. Shelley, L. I. (2020): *Illicit trade and terrorism*. Perspectives on Terrorism, 14(4), 7-20.
12. Thünen: Implementation and effects of the EU Timber Regulation (thuenen.de)
13. United Nations Security Council (2014), op. cit.
14. Zhang, J.; Gan, J. (2007): *Who will meet China's import demand for forest products?*. In: World Development, 35, 12, pp. 2150–2160
15. World Customs Organization (2013): *Illicit Trade Report 2012*. URL: http://www.wcoomd.org/-/media/wco/public/global/pdf/ topics/enforcement-and-compliance/activities-and-programmes/illicit-trade-report/itr_2012_en.pdf?db=web (accessed 1.3.2024.)

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OPPORTUNITIES FROM PARTICIPATION IN GLOBAL VALUE CHAINS OF BULGARIAN FURNITURE ENTERPRISES

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Abstract: Companies involved in global trade and manufacturing are actively engaging in global value chains (GVCs). Nevertheless, a significant number of Bulgarian furniture enterprises are not involved in these chains. The paper aims to outline the vision of the managers of some Bulgarian furniture enterprises related to the benefits of participating in GVCs and the current managerial practices related to it. The primary research methods are logical, deductive, and comparative approaches, along with analysis and synthesis methods. Data from online questionnaires distributed among managers of Bulgarian furniture companies is presented as well. Some of the outcomes of the analyzed answers are indicative that the inadequate understanding of Global Value Chains among managers, coupled with a low level of involvement in these chains, results in limited competencies within management teams.
Keywords: global value chains; furniture enterprises; questionnaires

1. INTRODUCTION

Global value chains (GVCs) have a crucial role in transforming business sectors by improving productivity and creating new job opportunities (Qiang et al., 2021). However, COVID-19 has revealed many weaknesses of the GVCs. This was a reason the European Union’s objective to shift towards shortening the chains and reducing the Union's dependence on foreign markets. A key challenge for effective participation in global value chains is to develop a new perspective of the companies to identify potential benefits while reducing chain risks and prioritizing the supply of key raw materials. Exploring potential opportunities at each stage of the chain requires higher-level skills, learning, complex technological capabilities (Pietrobelli and Rabellotti, 2011, p. 1262), and positive managerial attitudes towards participation in GVCs. Previous studies in the field report reluctance of Bulgarian enterprises to participate in GVCs (Georgieva, 2023; Georgieva et al., 2022). This requires additional studies related to the managerial vision of the risks and opportunities as a factor of participation in such chains.

The study of managerial attitudes in the forest industry underpins recent research on global value chain and supply chain issues. Untapped potential in this area is particularly important in the context of crisis management and global resource and staffing issues. Managers of the majority of small and medium-sized enterprises have for years realized the advantages of cooperation with large enterprises as well as with smaller ones, but still encounter great difficulties in implementing them despite positive attitudes. It is of interest whether after and in conditions of different types of crises the managers of furniture enterprises rely on strategic partnerships and inclusion in value chains as part of their anti-crisis management and how they evaluate the benefits of this.

The paper aims to outline the attitudes of the furniture enterprises' management regarding the benefits and negative sides of their participation in global chains. The adopted research methods are based on the logical, deductive, and comparative methods, as well as on the methods of analysis and synthesis. For the empirical study data from on online questionnaire during the period from November 2023 to February 2024 among managerial representatives of Bulgarian furniture enterprises are presented.

2. LITERATURE REVIEW

Chiu (2014) argues that supply chain diversity allows companies to innovate, diffuse new skills and technologies as well as to improve their assimilative power. Humphrey and Schmitz (2002) state that companies' participation in GVCs can lead to process innovations, reducing the cost of the manufactured product or service by more efficiently converting input materials and resources into a final product (service). Additionally, it can lead to expanding the product portfolio, producing higher quality products and services, and increasing the added value of the labor. Participation in GVCs helps local manufacturers to learn from global leaders. In some cases, the technologies and the know-how that are transferred from global leaders to local firms are limited to product information and production techniques (Gereffi and Kaplinsky, 2001). It leads to a lack of diffusion of intensive knowledge and skills in the workforce, which does not allow for increasing the value added along the chain. A major reason is the reluctance of global leaders to transfer knowledge that can subsequently be used in the local market by potential competitors. The problems of interfirm cooperation in the forest industry have been the subject of research for many years, in various aspects of cooperation. Large-scale studies on the subject have been carried out in connection with the participation of furniture enterprises in Bulgarian clusters and on the occasion of innovation cooperation in the sector. All of them show positive attitudes on the part of managers to participate in production chains and entrepreneurial networks, but low levels of collaboration and cooperation. (Popova 2008; Ivanova and Popova, 2009a, 2009b; Chobanova et al. 2018, p. 129).

Among the strategic problems of the enterprises over the years, leading to the low activity are the weak innovation and management culture, lack of qualified specialists, and low level of payment in the sector. Along with the unattractive working conditions in production mainly in the forest areas, the process of increasing the innovativeness and competitiveness of the enterprises becomes very slow. A key challenge for effective participation in global value chains is related to developing a new perspective to identify benefits and possible future threats while reducing risks along the chain and prioritizing the supply of key raw materials. Maintaining stocks of essential raw materials is also an opportunity to reduce shocks along the chains from future uncertainty in the economic, political, and health environment. Such a stock essentially contradicts the effective implementation of the Just-in-Time system, which is why proper logistics and the achievement of an appropriate balance in the warehouse holdings of enterprises are necessary. Enterprises even expect a deterioration of the added value along the chains and even the collapse of some of them. However, this attitude is not a result of COVID-19, but rather an overall vision and attitude of the managers regarding the benefits of participating in GVCs (Georgieva, 2023).

3. SURVEY METHODOLOGY AND RESULTS

The survey was conducted during the period from November 2023 to February 2024 and underwent a pilot phase to refine and enhance the questionnaire. The initial pilot survey was instrumental in identifying areas that needed improvement in the questionnaire design. Feedback and insights gathered from the pilot survey were carefully considered to make necessary enhancements and modifications, ensuring the questionnaire's effectiveness for the main survey. The final questionnaire, consisting of three main categories of questions was distributed online among furniture companies, operating in Bulgaria. 106 filled-in questionaries were collected and analyzed. The primary objective of the survey was to provide insights into the risks and opportunities associated with achieving innovativeness through participation in global value chains, specifically from a managerial perspective. The collected data were analyzed using IBM – SPSS Statistics, version 19.

From a socio-demographic standpoint, approximately 36% of the respondents held the position of CEOs, while around 42% were founders, and the remaining respondents represented various management departments within the furniture enterprises. Around 65.1% of the respondents acknowledge that their company do not participate in Global Value Chains (GVCs). The perceived risks associated with companies' participation in global value chains (GVCs) for value addition, as reported by the respondents, encompass several key dimensions. The concerns include:

- Apprehension by 3.8% of respondents about the vulnerability of their data, potential theft of intellectual property, and the risk of business ideas being compromised.
- The regulatory landscape is perceived as intricate, indicating challenges for companies navigating the legal requirements associated with participation in GVCs. This risk is expressed by 5.7%
- A substantial portion of respondents (28.2%) highlights the risk of dependency on other companies within the value chain, signaling concerns about potential disruptions or reliance issues.
- Wage disparities are identified as a risk, suggesting that companies are mindful of the potential social and ethical implications associated with participating in global value chains. Hence, wage inequality is considered as a risk by 7.5% of the respondents.
- Nearly one-fifth of respondents (19.8%) express concerns about limitations on their freedom to make decisions, indicating potential challenges in autonomy within the value chain.
- The reluctance to share knowledge and technology along the value chain is recognized as a risk by 5.7%, pointing to potential barriers in collaboration and information exchange.
- Changes in exchange rates impacting raw material prices are perceived as a risk by a small percentage of respondents (1.9%), reflecting concerns about financial volatility.
- Almost one-fifth of respondents (18.9%) identify delayed deliveries as a risk, indicating concerns about the timely and efficient flow of goods within the value chain.
- The risks associated with economic interdependence and susceptibility to external shocks are acknowledged by some respondents (5.7%), reflecting concerns about global economic dynamics.

- A minority of respondents (2.8%) perceive GVCs as not being a genuine part of the local economy, suggesting skepticism about the tangible benefits of such participation.

In summary, the identified risks highlight the multifaceted challenges and considerations that companies weigh when engaging in global value chains for value addition. The various concerns underscore the complexity of managing operations within a globalized and interconnected business environment.

Furthermore, the managers surveyed assert that Bulgarian companies lack the knowledge to handle the risks associated with Global Value Chains (GVCs). There is a noted deficiency in managerial comprehension of the essence of GVCs (13.2%), contributing to restricted competencies within management teams due to the low level of participation in these chains (3.8%) (see Figure 1).

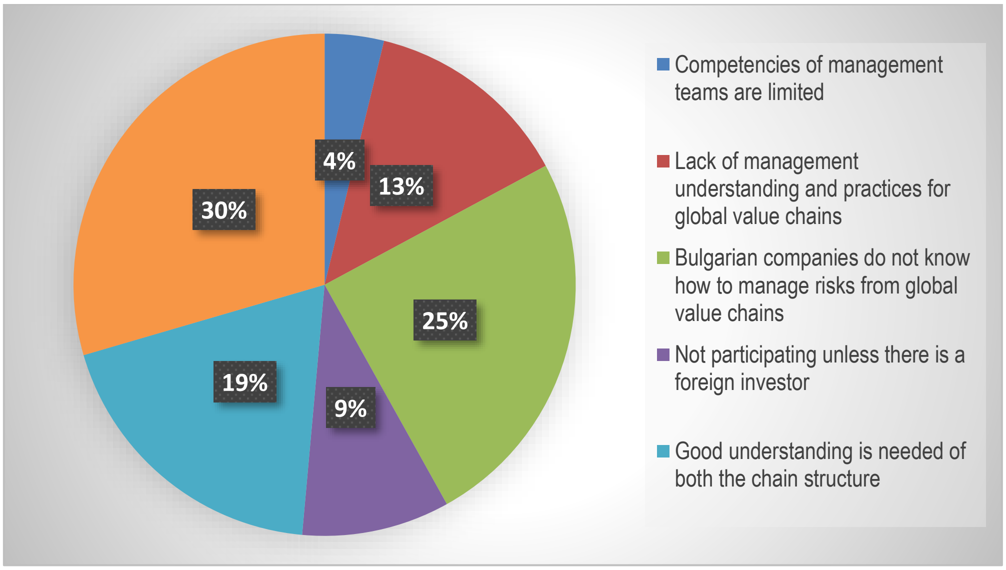

Figure 1. Answers related to management practices in Bulgarian companies about their involvement in global value chains, N=109

The survey sought to understand the managerial view related to the benefits of enterprise participation in Global Value Chains (GVCs). A small percentage of respondents (2.8%) acknowledge that participation in GVCs contributes to the development of their innovative potential. This suggests that for some companies, involvement in GVCs is perceived as a catalyst for fostering innovation. Another minor percentage (1.9%) emphasizes the motivation to provide competitive products. This indicates that some companies view GVC participation as a means to enhance their competitiveness in the market. A significant portion of respondents (9.4%) recognize the value of GVCs in facilitating the sharing of technological advancements and other relevant information. This highlights the importance of information exchange within the value chain. Over 12% of respondents identify the formation of new partnerships as a positive outcome of GVC participation. This underscores the networking and collaboration opportunities that arise from engagement in global value chains. A notable percentage acknowledges the positive impact of GVCs on staff qualifications (7.5%). This suggests that participation in global value chains may contribute to skill development within the workforce. More than 11% of respondents emphasize the role of GVCs in facilitating the exchange of knowledge and the dissemination of established practices. This underscores the learning opportunities inherent in global value chains. A small percentage recognizes the promotion of research and development activities (4.7%) as a benefit of GVC participation. This suggests that some companies see GVCs as supportive of their innovation-focused initiatives. Almost 9.5% of respondents highlight the importance of GVCs in providing access to customers. This indicates that participation in global value chains can enhance market reach for companies. A moderate percentage acknowledges that GVC participation grants access to additional investment funds (5.7%). This suggests the financial benefits associated with engaging in global value chains. Over 12% of respondents believe that GVCs enable companies to conquer new markets. This underscores the market expansion opportunities that arise from participation in global value chains. A significant percentage recognizes the advantage of using cheaper resources (17.9%) through GVC participation. This emphasizes the potential cost efficiencies associated with accessing resources within the value chain. A small percentage acknowledges that GVC participation can reduce risks for the firm from unforeseen circumstances (4.7%). This suggests a perceived risk mitigation aspect associated with involvement in global value chains.

4. CONCLUSIONS

According to the opinion of the Bulgarian managers, the key problems in the participation of GVC enterprises are related to a lack of knowledge and competencies for the management of risks arising from the complexity of the management of products and processes in these chains.

The results of the conducted research highlight some opportunities for participation in GVC, which should be used of Bulgarian furniture companies such as:

- Increasing of the innovation potential and innovation cooperation;
- Increasing of the competitiveness and technological transfer;
- Improving of the qualifications and developing the competencies of employees;
- Increasing of the market share and access to new markets;
- Increasing of the sources of financing product and process innovations;
- Increasing of the access to cheaper resources and effective cost management.

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REFERENCES

1. Chiu, Y.C. (2014): *Balancing exploration and exploitation in supply chain portfolios*, Engineering management, IEEE Trans. Eng. Manage. 61 (1): pp. 18-27.
2. Georgieva, D. (2023) *Challenges to the participation of innovative Bulgarian enterprises in global value chains, Trends and strategies for the recovery of the economic and social system after the Covid-19 pandemic*, Publishing Complex – UNWE. pp. 337-346. ISBN: 978-619-232-750-7.
3. Georgieva, D., Mitkova, M., Georgieva, T. (2022): *Global value chains in agriculture by the example of Bulgarian farmers*. KNOWLEDGE – International Journal, (55)1: pp. 51-56. ISSN 1857-923X (for e-version). ISSN 2545 – 4439 (for printed version)
4. Gereffi, G., Kaplinsky, R. (2001): *The Value of Value Chains.* IDS Bulletin Transforming development knowledge. 32(3).
5. Humphrey, J., Schmitz, H. (2002): *How does insertion in global value chains affect upgrading in industrial clusters?* Regional Studies. 36(9): pp. 1017–1027.
6. Ivanova D., Popova, R. (2009b): *Research of the experience of SME for furniture production in the area of cooperation*. VII International Scientific Conference "Management and Engineering"- Sozopol. Conference Proceedings. 3(113)/2009: pp. 93-98. ISSN 1310-3946.
7. Ivanova, D., Popova, R. (2009a): *The new forms of cooperation of woodworking and furniture enterprises - problems and perspectives*. XI International Scientific Conference "Management and Sustainable Development" – Yundola. Journal "Management and Sustainable Development". (11) 22: pp. 159-166. ISSN 1311-4506.
8. Pietrobelli, C., Rabellotti, R. (2011)*: Global value chains meet innovation systems: Are there learning opportunities for developing countries*? World Dev. 39(7): pp. 1261–1269.
9. Popova R. (2008): *Cluster form of organization - essence, application, guidelines for development.* XVII National scientific conference "Management and quality" for young scientists – Yundola. Collection of scientific works. pp. 131 -138 ISBN 954-323-057-9.
10. ***: Chobanova R., Kocarev L., Popova R., Georgieva V. D., Trayanov, Z., Traichevska, D., Angelova, R. (2018): *Forestry sector in Bulgaria and Macedonia*. Institute at the Bulgarian Academy of Sciences. ISBN 978-954-931.
11. URL: http://css.iict.bas.bg/eLibrary/PDFs%20for%20Platforms/Book-Forestry%20Sector%20in%20Bulgaria%20and%20Macedonia-en.pdf
12. ***: Christine Zhenwei, Q., Yan, L., Steenbergen, V. (2021): *An Investment Perspective on Global Value Chains*. Washington, DC: World Bank.
13. URL:https://openknowledge.worldbank.org/handle/10986/35526

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FORECASTING THE TRENDS FOR THE DEVELOPMENT OF GLOBAL VALUE CHAINS: THE CASE STUDY OF THE FURNITURE AND AGRIBUSINESS SECTORS

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Abstract: Technological value chains are a traditional channel for organizing economic activities and processing raw materials into final products. When they include producers from different countries and are globally represented, they become particularly vulnerable to the impact of global and regional crises. In this context, the purpose of the report is to forecast the main trends for the development of global value chains in the field of forestry and furniture sectors. The study is based on Delphi method – an expert-based survey that takes place in several stages and embraces the opinion of leading experts on the topic. The report presents the methodology for applying Delphi method and the results of the conducted research.
Keywords: global value chains, Delphi method, forestry and furniture sectors

1. INTRODUCTION

Economies put increasing efforts into their competitive positions. In recent years, there has been a fundamental change in the management and organisation of innovation processes. The analysis of foreign investment flows and the concentration of production processes at an international level show that the innovation capacity and technological competencies, once concentrated at the head offices of multinational enterprises, are increasingly being outsourced towards their peripheries and are being performed by companies located outside major economic centres. In this context, global value chains attract the attention of both the academic community and the political level as a factor for economic transformation and growth of local economies. Combined with the foreign investment flow, they provide a channel for the dissemination of technological knowledge, entrepreneurial culture and innovation capacity, changing the profile of related economic sectors and regions in which they are concentrated.

A wood furniture manufacturer could enhance its performance within the value chain and network by either enhancing the efficiency of its manufacturing processes or transitioning from manufacturing to focusing on product design (Abonyi, 2006). GVCs have become relevant in development policies through international organizations and the national development agencies of foreign donors. GVC participation has been regarded as a crucial component of national development strategies, but the predominant elements adopted from GVCs are largely market-oriented and centre on the export sector. Hence, GVCs could transform not only the companies but whole industries and countries (Staritz, 2012; Dallas, 2014). Some authors highlight the potential for local producers to acquire knowledge from the leading entities within the chains, which can be either buyers or producers (Gereffi, 1994; Gereffi and Kaplinsky, 2001). Moreover, the literature emphasizes the role of GVC leaders in disseminating knowledge throughout the chains. For small firms situated in less developed nations, engaging in value chains could give them access to a global market (Humphrey and Schmitz, 2000). In this respect, Global value chains yield significant economic advantages for both the participating companies and the national and regional economies involved (OECD, 2013).

The furniture industry is traditionally labour-intensive with a fragmented supply chain where many stages of production are often outsourced (Study on the EU furniture market situation and a possible furniture products initiative, 2014, p.17). Furniture manufacturers are investing in augmented reality technologies, such as virtual 3D models of furniture in real-time room settings, to support marketing, sales, and customer decision-making (Furniture Global Market Report 2021). Research in the field indicates that companies in the furniture manufacturing sector allocate more funds to the acquisition of machinery and equipment rather than to research and development (Pinkard and O'grady, 2016; Stefanov, 2020). Similarly, the development of the agro sector and the creation of its basis for national competitive advantages depend on the innovation activity of the links in the sectoral innovation system (Mileva & Georgieva, 2022). As a result of low productivity and profitability, lack of financial security, and adaptability to changes (Bashev & Koteva, 2021), more than one-third of all farms in Bulgaria have a low level of competitiveness (Mileva & Georgieva, 2022). However, investigating the potential innovative opportunities at each stage of the chain requires learning, creating, and acquiring skills of higher level and more complex technological capabilities.

The purpose of the study is to forecast the prospects for the development of global value chains through the application of the Delphi Method in the furniture manufacturing and agribusiness sectors. The Delphi method is an expert-based survey that takes place in several stages – most often there are three stages. The experts' responses are analysed and summarized after each stage. In each subsequent stage, survey participants receive aggregated feedback on the answers given by the experts in the previous stage. The aim is to reach a consensus among participating experts on realistic and feasible perspectives for the development of global value chains.

2. SURVEY METHODOLOGY, RESULTS AND DISCUSSIONS

2.1. Methodology

Data collection took place between April and August 2023. Over 30 experts from the forestry and agriculture sectors were identified and invited by email to participate in the study. The data was collected using an online tool ('Unipark'), and the experts had two to three weeks to provide their responses. Completion of the questionnaire could be interrupted and resumed at a later stage. While the questionnaires in each of the three rounds were active, all participants received several reminder emails to increase the response rate. Questionnaires for the three rounds of the Delphi survey were prepared together with the project team members and tested before they were uploaded to the Unipark platform used to implement the survey.

2.2. Research results and discussion

The final result of the three rounds is the summary opinion of the participating experts on the impact of global chains on the economic development of the regions where the enterprises participating in them are located, on the benefits and risks for the enterprises, especially in terms of their innovation potential and their growth, and also on the role, implementation and effectiveness of European and national policies for the purposes of global value chains. Table 1 presents a summary of the opinions of the experts.

Table 1. Summary of the experts' opinions on the main questions discussed

Question 2: What is the strongest interaction between participants in global value chains?	
For this question, the experts were instructed in the first round to name the five most important modes of interaction in their opinion, choosing from a predetermined set of possible answers. In the second round, they were asked to rank the answers in order of importance, having previously been informed of the ranking in the previous stage. The five most important interactions between GVC participants are:	1. Innovation activity. 2. Logistics of raw materials, materials, semi-finished products. 3. Production of products and services. 4. Exchange of experience and ideas. 5. Research and development activity.
Question 3: In what specific ways do global value chains affect regional economies?	
In this question, as in the previous one, the experts in the first round indicated five of the pre-set possible answers. In the second round, they were informed about the arrangement in the previous round and had the opportunity to change their answers. The most important ways in which GVC affect regional economies are:	1. Competitiveness. 2. Innovation potential of the regional economy. 3. Innovation potential of the business.
Question 5: Are there circumstances where participation in global value-added chains may negatively impact regional development?	
In the first round, the experts shared 44 proposals, which after analysis were summarized in 12 different circumstances. In the second round, the experts agreed with six of them. After the third round, the following five circumstances emerged as the most important:	1. The more active/larger participants in the GVC can gain a dominant position and manipulate the participation of the less active/larger ones. 2. Participation may lead to a reduction in regional production, regional development activity and the workforce in the given field.

	3. Price pressure from larger players in the chain can lead to the destruction of local entrepreneurial businesses, due to the importation of products of lower quality and much lower price. 4. The war in Ukraine / wars / political crises. 5. Predatory use of resources and environmental pollution.
Question 11: What should be the role of national policies and local institutions in creating industrial areas for rapid development and participation in global value chains?	
The experts were extremely motivated on this issue, and offered as many as 58 opinions on the role of political institutions at the national and local level. In the second round, they had to say how much they agreed with the formulated 18 statements. Somewhat surprisingly, all 18 received over 75% support, and 6 of them over 90%. Logically, the large number of claims resulted in the votes being spread out in the third round, and only three of the claims received about or over half of the possible votes. These three views on the role of policies are:	1. Political institutions must first of all provide conditions for the successful training of people, and not provide buildings, grounds, etc. material prerequisites. 2. Provision of conditions for investments, low taxes for start-up businesses, support for small and medium-sized enterprises, tax breaks for companies participating in the chain. 3. Modernization of the digital infrastructure.
Question 12: Where should the emphasis of national policies related to the digital transition be placed in order to support Bulgarian companies in this process?	
And this question provoked the experts to think - 55 proposals for political priorities in the field of digital transition were made in the first round. After analysis, 14 summary proposals were evaluated in the second round. Two of them remained below the barrier and were not voted in the third round. Only two proposals received half	1. Improving our national cyber security policy and ensuring a safe electronic environment. 2. Promotion of cooperation between academic circles and Bulgarian companies.

the votes (9). Two more of these were named as most important by six experts.	3. Construction of information systems and portals for exchange of practices. 4. Appropriate digital infrastructure, fast and accessible internet.

3. CONCLUSION AND RECOMMENDATIONS

The main objective of the Delphi survey conducted was to gather expert opinions on the different dimensions of global value chain operations in their respective sectors. In particular, the emphasis was placed on the influence of GVC on the Bulgarian furniture and acriculture companies included in them. The experts also assessed the wider impact of GVC on the competitiveness of the regions where these companies are located.

In the first stage of the Delphi survey, 23 experts took part, who expressed their views and opinions on GVC, as well as the benefits and challenges of the participation of Bulgarian companies in these chains. A total of 600 responses were received to the 15 questions. After analysis, these 600 responses were summarized into 200 statements.

In the second stage, 18 participating experts expressed their agreement or disagreement with these statements. All statements that reached an endorsement rate of 75% or more were included in the third and final stage of the Delphi survey. At this stage, the 18 participating experts voted and thus selected the most important statements. Thus, we found out which views, perceptions and opinions about GVC are the most significant according to the experts.

The experts were provided with information about the degree of endorsement of the statements from the second stage before ranking the statements according to their importance. This information appears to have had little effect on their assessment. For the majority of statements, the order remained the same in the second and third stages—those with the highest endorsement ratings in the second stage were selected as most important in the third. A slightly more significant change in the order of statements was observed only for questions 11, 12, 13 and 14. This shows that despite the relatively long period between the second and third stages (about one month), the experts' opinions are stable and sustainable.

As a priority, experts engaged in the Delphi survey view involvement in Global Value Chains as enhancing regional competitiveness and innovation capabilities of the furniture manufacturing companies and the companies from the agribusiness sectors. Advantages emerge at the company's level by focusing on building innovativeness and competencies, outsourcing ancillary tasks, achieving cost-effectiveness or improving the quality of the production. Fostering competition in domestic input markets, and benefiting from knowledge transfer from multinational enterprises are additional benefits for the furniture and agribusiness companies.

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REFERENCES

1. Abonyi, G. (2006): *Linking Greater Mekong Subregion Enterprises to International Markets: The Role of Global Value Chains*. International Production Networks and Enterprise Clusters, United Nations publication, p. 16-21, ISBN 13: 978-92-1-120492-6
2. Bashev, H., Koteva, N. (2021): *Competitiveness of Agricultural Farms in Bulgaria*. Economic Thought, 3-26.
3. Dallas, M. (2014): *Cloth without a Weaver: Power, emergence and institutions across global value chains*. Economy and Society, 43(3), 315–345
4. Furniture Global Market Report 2021: COVID-19 Impact and Recovery to 2030.
5. Gereffi, G. (1994): *The Organization of Buyer-Driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks*. In Commodity Chains and Global Capitalism, ed. G. Gereffi and M. Korzeniewicz. London: Praeger . 1999. International Trade and Industrial Upgrading in the Apparel. Commodity Chain. Journal of International Economics 48:37–70.
6. Gereffi, G.; Kaplinsky, R. (2001): *The Value of Value Chains [Special Issue]*. IDS Bulletin 32
7. Humphrey, J., Schmitz, H. (2000): *Governance and Upgrading: Linking Industrial Cluster and Global Value Chain Research*. Working Paper No. 120, Institute of Development Studies, University of Sussex, Brighton, U.K
8. Mileva, S., Georgieva, T. (2022): *Sectoral innovation system of agribusiness in Bulgaria – main challenges and perspectives*. Access to science, business, innovation in digital economy, ACCESS Press, 3(3), 307-338. https://doi.org/10.46656/access.2022.3.3(9)
9. OECD (2013): Interconnected Economies: Benefiting from Global Value Chains, OECD
10. Pinkard, E. A.; O'grady, A. P. (2016): *Innovation in the Forest Industry: Ready or Not!* Australian Forestry. 79(3): pp. 153-156
11. Staritz, C. (2012): *Value chains for development? Potentials and limitations of global value chain approaches in donor interventions* (ÖFSE Working Paper No. 31). Vienna: ÖFSE
12. Stefanov, N. (2020): *The Impact of the Cap on the Sustainability of Forestry Sector in Bulgaria*. Journal of Bio-based Marketing. (2): pp. 29-41
13. Study on the EU furniture market situation and a possible furniture products initiative (2014).

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FINTECH AND THE FORESTRY INDUSTRY

Deyan Radev

Abstract: This study explores the transformative potential of fintech in the forest-based sector, unveiling a landscape where technology intersects sustainability. To this end, the paper demonstrates how blockchain, AI-driven precision forestry, crowdfunding, tokenization, and community-engaging apps reshape forestry practices. Amid promises, challenges of regulatory compliance, economic risks, and environmental considerations emerge. The conclusion calls for collaborative innovation, responsible practices, and interdisciplinary research to harness fintech's potential sustainably. Focusing on future research venues, the paper envisions a forest-based industry positioned as a global leader in responsible forestry, economic resilience, and environmental stewardship.
Keywords: Fintech, forestry, development, artificial intelligence, blockchain, financial services, digitalization

1. INTRODUCTION

The relationship between financial technology (fintech) and traditional industries has played a central role in contemporary economic transformations. The term fintech broadly refers to the application of cutting-edge technologies to enhance and automate financial services. These technologies encompass a spectrum ranging from artificial intelligence (AI) and blockchain to mobile applications and data analytics. The dynamism inherent in fintech innovations has demonstrated their capacity to redefine traditional business models across various domains, transforming how transactions are conducted, data is managed, and financial services are delivered (AlBenJasim et al., 2023; Alam, 2023). As technological advancements reshape the landscape of various sectors, the intersection of fintech with industries such as finance, healthcare, and manufacturing has garnered substantial attention. However, an area that remains underexplored, yet of paramount importance for both economic and environmental considerations, is the connection between fintech and the forest-based industry. This paper seeks to fill this gap, delving into the implications and opportunities that arise at the intersection of financial technology and forestry.

The forest-based industry, encompassing forestry, logging, wood processing, and related activities, stands as a cornerstone of global economies and ecosystems (FAO, 2021). Sustainable management of forests is not only necessary for maintaining biodiversity and mitigating climate change but also critical for supporting livelihoods and economies worldwide. Historically, the forest-based industry has navigated challenges such as illegal logging, supply chain opacity, and inefficiencies in resource allocation. However, the emergence of fintech introduces a transformative wave of possibilities, promising to address longstanding issues and elevate the industry's sustainability and profitability.

The forest-based industry, operating within a traditional framework, has the potential to benefit substantially from fintech integration. Fintech's ability to streamline financial processes, enhance transparency, and facilitate access to capital holds deep implications for sustainable forestry practices. By investigating this linkage, we can discern how fintech applications contribute to operational efficiency, environmental sustainability, and financial inclusion within the forest-based industry. Additionally, understanding this synergy is essential for policymakers, industry practitioners, and researchers alike to navigate challenges, leverage opportunities, and guide the sector towards a more sustainable and technologically-driven future.

The chapter is structured as follows. Section 2 discusses the overall impact of fintech on the forestry industry. Section 3 discusses opportunities and future trends, while Section 4 concludes and outlines recommendations and venues for future research.

2. IMPACT OF FINTECH ON THE FOREST-BASED INDUSTRY

This section delves into the deep impacts that fintech integration has on the forest-based industry, going beyond traditional practices and shaping a dynamic landscape. From financial processes to sustainable forestry management, the influence of fintech passes through the entire supply chain, offering both challenges and opportunities.

2.1. Financial Transformation in the Forest-Based Industry

Fintech's entrance into the forest-based industry has led to a financial transformation, revolutionizing the way financial transactions are conducted, recorded, and managed within forestry operations.

- **Streamlining Financial Processes:** The adoption of digital payment solutions has streamlined financial processes within the forest-based industry. Mobile applications and online platforms facilitate the seamless transfer of funds, reducing reliance on cumbersome and time-consuming traditional banking methods. This not only enhances operational efficiency but also minimizes transactional friction (see, e.g., AlBenJasim et al., 2023).
- **Enhanced Transparency:** Blockchain technology, a key component of fintech, has introduced unprecedented transparency into financial transactions within forestry. By providing a decentralized and tamper-resistant ledger, blockchain ensures that every financial interaction—from the sale of timber to the distribution of funds—is securely recorded and verifiable. This transparency fosters trust among stakeholders and addresses concerns related to fraudulent activities (see, e.g., Alam, 2023).
- **Financial Inclusion for Small Enterprises:** Fintech applications have played a pivotal role in promoting financial inclusion for small and medium-sized enterprises (SMEs) in the forest-based industry. Digital payment solutions enable these enterprises to access banking services, facilitate transactions, and establish a financial identity. This inclusivity contributes to the economic empowerment of SMEs, fostering a more resilient and diverse forest-based sector (see, e.g., World Bank, 2023).
- **Risk Mitigation through Smart Contracts:** Smart contracts, enabled by blockchain, automate and enforce financial agreements within forestry operations. This not only reduces the risk of contractual disputes but also ensures that all parties adhere to predefined terms. The automation of contract execution through smart contracts contributes to risk mitigation and operational efficiency (see, e.g., Alam, 2023).

2.2. Supply Chain Transparency and Traceability through Blockchain Technology

Blockchain, a disruptive fintech innovation, has far-reaching implications for the supply chain within the forest-based industry. Its application enhances transparency and traceability, addressing critical issues related to illegal logging, sustainable sourcing, and certification.

- **Traceability of Timber Products:** Blockchain's decentralized ledger ensures the traceability of timber products throughout the entire supply chain. From the moment a tree is harvested to the processing and distribution of wood-based products, every transaction is securely recorded. This traceability not only addresses concerns related to illegal logging but also provides consumers with assurance regarding the authenticity of sustainably sourced wood (Alam, 2023).
- **Smart Contracts for Transparent Agreements:** Smart contracts embedded in blockchain facilitate transparent agreements within the supply chain. These contracts, automatically executed when predefined conditions are met, eliminate the need for intermediaries and ensure that contractual terms are adhered to. This transparency reduces the risk of disputes and discrepancies, fostering a more efficient and reliable supply chain (Alam, 2023).
- **Certification and Compliance:** Blockchain offers a secure and transparent means of recording certification and compliance data within the forest-based industry. Certifications such as those provided by the Forest Stewardship Council (FSC) can be securely stored on the blockchain, verifying that timber products meet sustainability and legality standards. This not only streamlines certification processes but also builds trust among consumers and regulatory bodies (see, e.g., He and Turner, 2022).

2.3. AI and Machine Learning for Sustainable Forestry Management

Fintech's integration with artificial intelligence (AI) and machine learning (ML) technologies has important implications for sustainable forestry management. From precision forestry to predictive analytics, these technologies contribute to informed decision-making and the optimization of forestry operations.

- **Precision Forestry:** AI and ML algorithms analyze vast datasets, including satellite imagery and geospatial data, to identify patterns and trends in forest ecosystems . This enables precision forestry, where decisions related to harvesting, thinning, and reforestation are based on real-time and predictive insights. Precision forestry minimizes environmental impact, enhances resource efficiency, and promotes sustainable land management (see, e.g., Iglseder et al., 2023).
- **Predictive Analytics for Forest Health:** AI-driven predictive analytics assess factors such as tree health, susceptibility to pests, and fire risk. By forecasting potential threats to forest health, forestry managers can proactively implement measures to mitigate risks. This proactive approach not only preserves the ecological balance of forest ecosystems but also ensures the long-term sustainability of forestry operations (Iglseder et al., 2023).
- **Optimizing Harvesting and Logistics:** Machine learning algorithms optimize the planning and scheduling of harvesting operations within sustainable forestry practices. By considering factors such as terrain, weather conditions, and transportation logistics, AI can create efficient harvesting plans. This not only reduces environmental impact but also

minimizes operational costs, contributing to the overall economic viability of sustainable forestry (Iglseder et al., 2023).

- **Ecosystem Services Valuation:** AI applications contribute to the quantification and valuation of ecosystem services provided by forestry. This includes the assessment of carbon sequestration, water regulation, and biodiversity conservation. Integrating these valuations into forestry management practices fosters a holistic approach that acknowledges the various benefits of forestry beyond timber production (He and Turner, 2022).

3. OPPORTUNITIES AND FUTURE TRENDS IN THE FOREST-BASED INDUSTRY

This section explores the different opportunities and future trends introduced by fintech in the forest-based industry, emphasizing the potential for innovation and sustainability.

3.1. Integration of Emerging Technologies

- **Blockchain for Carbon Credits and Emission Reduction:** Blockchain technology can facilitate the creation and trading of carbon credits within the forest-based industry. By securely recording and verifying carbon sequestration activities, blockchain ensures the transparency and authenticity of emission reduction efforts. This not only incentivizes sustainable forestry practices but also provides a mechanism for companies to offset their carbon footprints (He and Turner, 2022).
- **AI and ML for Precision Conservation:** The integration of artificial intelligence and machine learning in conservation efforts enhances precision and effectiveness. AI algorithms can analyze vast datasets to identify areas with high biodiversity value or those at risk of illegal logging. This precision conservation approach allows for targeted interventions, optimizing the allocation of resources for maximum impact (Iglseder et al., 2023).
- **IoT for Real-time Forest Monitoring:** The Internet of Things (IoT) can be leveraged for real-time monitoring of forest ecosystems. Connected sensors can provide data on environmental conditions, tree health, and even detect early signs of pests or diseases. This real-time data empowers forestry professionals to proactively manage and protect forest resources (Iglseder et al., 2023).

3.2. Sustainable Finance Innovation

- **Impact Investing Platforms:** Fintech platforms can play a crucial role in connecting impact investors with forestry projects aligned with environmental and social objectives. These platforms use technology to match investors' preferences with projects that focus on sustainable practices, biodiversity conservation, and community development. Impact investing in forestry through fintech channels contributes to the realization of both financial returns and positive environmental outcomes (Hörisch, 2015).
- **Tokenization of Forest Assets:** Fintech, coupled with blockchain, can further innovate sustainable financing by enabling the tokenization of forest assets. This allows fractional ownership and trading of digital tokens representing ownership in specific forest

projects. The tokenization model enhances liquidity, broadening the investor base and fostering inclusivity in supporting sustainable forestry initiatives (Alam, 2023).

3.3. Addressing Global Challenges

- **Fintech for Illegal Logging Prevention:** The application of fintech, particularly blockchain, can play a pivotal role in preventing illegal logging. By creating an immutable and transparent record of timber transactions, blockchain ensures that only legally sourced wood enters the supply chain. This not only addresses environmental concerns but also aligns with global efforts to combat illegal logging and promote sustainable forestry (He and Turner, 2022).
- **Fintech Solutions for Climate Resilience:** Fintech innovations can contribute to climate resilience in the forest-based industry. This includes the development of financial tools and insurance products that support forestry projects in adapting to and mitigating the impacts of climate change. Fintech solutions tailored to climate resilience enhance the sector's ability to navigate uncertainties and promote long-term sustainability (Alam, 2023).
- **Fintech-Driven Sustainable Development Goals (SDGs):** Fintech in the forest-based industry can be strategically aligned with the United Nations' Sustainable Development Goals (SDGs). Through innovative financial instruments, technology-driven conservation initiatives, and community engagement platforms, fintech can contribute to achieving SDGs related to environmental conservation, poverty alleviation, and responsible consumption (Hörisch, 2015).

Overall, the opportunities and future trends in the forest-based industry shaped by fintech are expansive and transformative. As the industry embraces emerging technologies, sustainable finance models, enhanced collaboration, and addresses global challenges, it positions itself at the forefront of innovation and sustainability. By leveraging these opportunities, the forest-based industry can not only optimize its operations but also contribute significantly to global environmental and social goals.

4. CONCLUSION: NAVIGATING THE FINTECH LANDSCAPE IN THE FOREST-BASED INDUSTRY

This exploration of the intersection between fintech and the forest-based industry reveals a transformative potential to redefine operations, sustainability practices, and economic dynamics. Fintech's transformative power is through enhanced transparency, efficiency, and sustainability, from blockchain combating illegal logging to AI-driven precision forestry optimizing resource allocation. However, challenges, including technological complexities, regulatory considerations, economic risks, and environmental impact concerns, necessitate strategic approaches and a commitment to responsible practices.

Looking ahead, research must focus on the evolving landscape of fintech in the forest-based industry. Studies addressing the dynamic interplay of technological advancements, regulatory frameworks, and industry-specific needs are essential. The role of fintech in promoting biodiversity, mitigating climate change, and achieving sustainable development goals warrants further exploration.

Additionally, longitudinal studies tracking the implementation and impact of fintech solutions over time will provide valuable insights into the scalability and long-term sustainability of these innovations. Comparative analyses of fintech integration across diverse forestry contexts and regions will contribute to the understanding of the contextual factors influencing success.

Overall, the integration of fintech in the forest-based industry is a journey marked by both promise and complexity. As the industry embarks on this transformative path, a commitment to collaboration, responsible practices, and ongoing research will be instrumental in realizing the full potential of fintech to foster sustainability, resilience, and innovation within the forest-based sector.

REFERENCES

1. Alam, T. Blockchain-Based Internet of Things: Review, Current Trends, Applications, and Future Challenges. Computers. 2023; 12(1):6. https://doi.org/10.3390/computers12010006
2. AlBenJasim, S., T. Dargahi, H. Takruri & R. Al-Zaidi (2023) FinTech Cybersecurity Challenges and Regulations: Bahrain Case Study, Journal of Computer Information Systems, DOI: 10.1080/08874417.2023.2251455
3. Gomber, P., Koch, J. A., & Siering, M. (2017). Digital finance and fintech: Current research and future research directions. Journal of Business Economics, 87(5), 537-580.
4. He, Z., and P. Turner. 2022. "Blockchain Applications in Forestry: A Systematic Literature Review" Applied Sciences 12, no. 8: 3723. https://doi.org/10.3390/app12083723.
5. Hörisch, Jacob. (2015). Crowdfunding for Environmental Ventures: An empirical analysis of the influence of environmental orientation on the success of crowdfunding initiatives. Journal of Cleaner Production. 107. 10.1016/j.jclepro.2015.05.046.
6. Iglseder, Anna & Immitzer, Markus & Dostálová, Alena & Kasper, Andreas & Pfeifer, Norbert & Bauerhansl, Christoph & Schöttl, Stefan & Hollaus, M.. (2023). The potential of combining satellite and airborne remote sensing data for habitat classification and monitoring in forest landscapes. International Journal of Applied Earth Observation and Geoinformation. 117. 103131. 10.1016/j.jag.2022.103131.
7. FAO. (2021). Global Forest Resources Assessment 2020 – Key findings. Food and Agriculture Organization of the United Nations. Retrieved from https://www.fao.org/3/ca8753en/ca8753en.pdf.
8. Pajkoš, Martin, Radomír Klvač, Jindřich Neruda, and Pawan Kumar Mishra. 2018. "Comparative Time Study of Conventional Cut-To-Length and an Integrated Harvesting Method—A Case Study" Forests 9, no. 4: 194. https://doi.org/10.3390/f9040194.
9. World Bank. (2023). Global Findex Database 2021. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/37578/9781464818974.pdf.

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EXPLORING THE IMPACT OF LOGISTICS ON SUSTAINABLE PRACTICES IN THE FORESTRY SECTOR

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Abstract: Over the past decades, there has been an increasing interest in sustainable practices and greenhouse gas emissions (GHG) in all economic sectors. Nevertheless, there are no detailed studies on the relationship between the application of sustainable practices in logistics that serves the forestry sector and the actual planning and implementation of those practices. This study will contribute to filling this gap in scientific literature by analysing the relationships and the practices implemented by 56 representatives of the senior management staff in logistics companies based in Bulgaria that also offer logistics services for the forestry sector. The objective of the study is to examine the method in which logistics companies related to the forestry sector adopt and apply sustainable practices and to analyse their perspective and attitude with respect to the issues of sustainability. For fulfilling this objective, the Multiple Correspondence Analysis (MCA) method has been used, which allows analysis of the relationships between the different categories of responses to the questions asked to survey participants. The results from the survey emphasise the positive attitude toward sustainable practices and their potential to improve the business related to the need of wider application of the sustainability reporting practices among logistics companies that provide services to the forestry sector.
Keywords: logistics, forestry sector, sustainability

1. INTRODUCTION

The issues of sustainability and environmental responsibility in the logistics sector are subject to active scientific research and discussions (Dimitrakieva et al., 2022; Gancheva, 2021; Kirechev, 2017; Kirecheva, 2022; Luhas, 2022; Pauliková and Chovancová, 2022). Many research sources present analyses, data and recommendations on the adoption and implementation of sustainable practices in logistics and also consider their impact on the business and the environment (Kalinova, 2023; Kanev, 2018; Mednikarov et al., 2019; Narleva et al., 2023; Palander and Vesa, 2022). One of the key directions of the research is analysis of the impact of logistics on environmental sustainability and conservation of natural resources (Vienažindienė et al., 2021). There are specialised scientific articles that discuss different aspects of logistics, including transport operations, storage (Deckert, 2020) and supply chain management, (Letunovska et al., 2023) and the level of impact from the environmental consequences. Most studies focus on the reduction of greenhouse gas emissions and on optimisation of transportation routes by introducing alternative and low-emission technologies and solutions. Different opportunities and benefits from the application of sustainable practices in logistics have been identified for the business in different sectors (Bakalova, 2023), including the forestry sector (Palander and Vesa, 2022). The scientific sources that provide an overview of different sustainable practices in the logistics sector have been shared, some of which are routes optimisation, use of low-emission transportation vehicles, recycling and reduction of waste, use of renewable energy sources and cooperation with suppliers that adhere to sustainable standards (Dimitrakiev et al., 2020; Dimitrakieva et al., 2023, 2022; Yotsov et al., 2017). Certain limited scientific research sources study the attitudes and level of application of sustainable practices by logistics companies serving the forestry sector. Logistics has the potential for positive impact and could contribute to minimising the adverse impact on the environment and to improving the business processes by its role to connect manufacturers, suppliers and final consumers.

The **objective of the study** is to examine the method in which logistics companies related to the forestry sector plan and apply sustainable practices by analysing their perspective and attitude with respect to the current issues related to sustainability.

2. METHODOLOGY FOR STUDYING THE IMPACT OF SUSTAINABLE PRACTICES IN THE FORESTRY SECTOR

Multiple Correspondence Analysis (MCA) has been used for this study as a suitable statistical method for analysis Software for Excel XLSTAT (Lumivero, 2024) of data related to categorical variables in the specific context of our study about sustainability in the forestry sector. The application of MCA allows identification and proper demonstration of the complex interactions and dependencies between the different categories of responses. The MCA analysis provides us with suitable information that can be used for taking informed decisions and for development of strategies for more sustainable management of processes in logistics. To examine the impact of sustainable practices on the forestry sector, we created a questionnaire designed to collect information from managers of logistics companies dealing with transportation of wood, wood processing materials and forestry products.

The questions included in the survey were as follows:

1. Do you think the application of sustainable practices in logistics contributes to the positive development of the business in the forestry sector? Possible answers: Yes, No
2. Does your logistics company apply practices for routes optimisation in order to reduce carbon leakage? Possible answers: Yes, No, Undecided
3. Please, mark the level of application of sustainable practices in your logistics company by indicating your preferences from 1 (the lowest level) to 5 (the highest level).
4. Does your logistics company actively apply practices to reduce waste from its operations? Possible answers: Yes, No, Undecided
5. Do you actively monitor your emissions, do you regularly fill out all GHG emission reports (Scope 1, 2 and 3) and do you actively monitor your emissions and your sustainability? Possible answers: Yes, No, Undecided

The analysis of the responses to these questions is expected to demonstrate whether logistics companies in the forestry sector adopt and apply sustainable practices and what their impact on the business processes is.

3. RESULTS

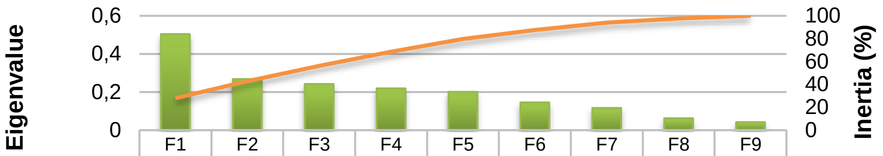
Sustainability turns out to be a critical consideration in economics and the logistics sector plays a key role there because of the significant impact on the environment. Climate change concerns and the depletion of resources become increasingly relevant and enterprises face a growing pressure to adopt sustainable practices. The forestry sector is closely linked to logistics due to the need of transportation of timber and related products, and understanding the perspectives and actions of logistics companies related to sustainability is of key importance for the assessment of their influence on the industry.

The analysis of the results from the responses to **question 1** shows that there is significant agreement among survey participants about the positive contribution of the implementation of sustainable practices in logistics to the development of the business in the forestry sector. Approximately 66% of survey participants clearly support this idea and believe that sustainable practices have a favourable effect. At the same time, 11% have responded negatively and 23% have stated they are undecided or do not have clarity on this aspect. Based on the results derived from the analysis, it can be concluded that the majority of players in this industry believe in the positive contribution of sustainability to the business.

The analysis of the results from **question 2** shows that a small percentage of the respondents (12.5%) apply practices for optimisation of the routes in their logistics company in order to reduce carbon leakage, whereas the majority of them (87.5%) do not apply such practices. The demonstrated low level of application of route optimisation practices shows the potential for improvement and investment in modern technologies and methods that would help reduce emissions generated from vehicles. Therefore, the opportunities for implementation of route optimisation practices in the sector can be considered as part of a strategical approach to sustainability and environmental responsibility.

The analysis of the responses given to the **third question** shows that implementation of sustainable practices is relatively widespread. The survey shows that the most common preferences regarding the level of implementation are scores from 4 to 3, which are given by the following percentage of respondents: 30.36% have given a score of 4 and 28.57% have given a score of 3. The average score is approximately 2.964, which implies that the majority of companies have made moderate efforts for implementation of sustainable practices in their operations. This result demonstrates the commitment of logistics companies to implement more sustainable and more environmentally friendly processes. Nevertheless, there are also differences among the responses with higher or lower scores, which demonstrates the variations in the strategies and the commitment to sustainability and protection of the environment. The analysis of the responses given to the **fourth question** about the active implementation of practices to reduce waste from operations shows that only 12 out of 56 respondents have answered "yes", while the remaining 44 responses are negative. This means that only 21.43% of the respondents have implemented practices to decrease waste from operations, while 78.57% have not implemented such practices. This result demonstrates the different level of implementation of strategies or challenges companies are faced with when introducing such practices. The implementation of practices to reduce waste from operations can have a positive contribution to sustainability in the business and to the protection of the environment. The analysis draws our attention to the need of further efforts to stimulate and support the implementation of such practices in the logistics sector. Regarding **question 5** which was about active monitoring of emissions and regular completion of all reports about greenhouse gas emissions, the responses show that only 8.93% of the respondents are actively monitoring their emissions and regularly fill out all greenhouse gas emissions reports. This result shows a significant potential for improvement in the field of monitoring and this would be of key importance for optimisation of the sustainability of operations in companies.

The Multiple Correspondence Analysis (MCA) was used to analyse the relationships between the different variables based on the data obtained and the overall volatility of data is 1.8. The eigenvalues constitute the amount of volatility explained by each dimension (component) derived in the analysis. Each eigenvalue corresponds to a key component. In this case, there are 9 eigenvalues (figure 1), where the first one is the largest (0.504), while the subsequent ones are decreasing. The overall volatility explained by each dimension (component) and, respectively, the cumulative percentage, shows in more detail how much volatility is explained cumulatively by adding more components, where in our case the first dimension F1 explains 28.003% of volatility, etc.



	F1	F2	F3	F4	F5	F6	F7	F8	F9
Eigenvalue	0,504	0,268	0,242	0,219	0,201	0,145	0,116	0,062	0,042
Cumulative %	28,003	42,883	56,335	68,500	79,661	87,740	94,198	97,659	100,000

Figure 1. Eigenvalue corresponds

In the course of the study, test values (variables) have also been identified, which show the contribution of each category of variables to each dimension *(Table 1)*.

Table 1. Test values (Variables)

Test values (Variables):	F1	F2	F3	F4	F5
Positive development of business-No	**-2,549**	**4,337**	**-3,395**	-1,298	0,327
Positive development of business-Yes	-1,393	-1,520	**5,963**	-0,427	-0,213
Positive development of business-dk	**3,847**	**-2,100**	**-3,813**	1,636	-0,046
Route optimization-No	**-5,314**	**-3,090**	**-2,999**	-0,838	0,763
Route optimization-Yes	**5,314**	**3,090**	**2,999**	0,838	-0,763
Implementation of sustainable practices 1 (lowest) to 5 (highest). -1	**-3,719**	**2,127**	**2,184**	-1,852	**3,615**
Implementation of sustainable practices 1 (lowest) to 5 (highest). -2	-1,212	**-4,225**	1,696	-0,049	**-4,489**
Implementation of sustainable practices 1 (lowest) to 5 (highest). -3	-1,145	**2,592**	**-2,475**	**5,479**	-1,904
Implementation of sustainable practices 1 (lowest) to 5 (highest). -4	**3,684**	**-3,158**	-0,328	0,366	**4,609**
Implementation of sustainable practices 1 (lowest) to 5 (highest). -5	**2,432**	**2,431**	-0,790	**-5,012**	**-3,097**
Reduce operational waste-No	**-5,608**	1,480	**2,323**	**2,453**	-0,360
Reduce operational waste-Yes	**5,608**	-1,480	**-2,323**	**-2,453**	0,360
Monitor your emissions-No	**-5,771**	**-2,396**	**-2,272**	-1,784	-0,122
Monitor your emissions-Yes	**5,771**	**2,396**	**2,272**	1,784	0,122
Monitor your emissions-No	**-5,771**	**-2,396**	**-2,272**	-1,784	-0,122
Monitor your emissions-Yes	**5,771**	**2,396**	**2,272**	1,784	0,122
Values displayed in bold are significant at the level alpha=0,05					

The positive values show a positive relationship, while the negative ones demonstrate a negative relationship. Larger absolute values suggest stronger associations. In the interpretation of the resulting test values (variables), it is important to pay attention to the specific values and their relationship to the set variables. For example, if we consider the "Route optimisation" row, we can notice that when route optimisation is present ("Yes"), all values of F1 through F5 are positive, where the largest positive value is for F3 (5.314). This may show that route optimisation is closely related to increased levels of certain aspects of the business development, such as monitoring of emissions (F3). On the other hand, when the values for route optimisation ("No") and the values of F1 through F5 are negative, the most negative value is for F1 (-5.314). This result shows the opposite situation, where the lack of route optimisation may be related to decreased development of the business, especially with respect to aspects such as sustainable practices (F1). Similarly, the other variables have also been analysed and the interactions between them and the specific aspects of business development have been studied. The conclusion drawn from the results obtained is that the values of F1 and F5 are associated with the implementation of sustainable practices, while F3 is more associated with monitoring of emissions. In the survey, the values written in bold are significant at level 0.05 alpha, which means that the associations observed are unlikely to have emerged by chance. Such analyses are recommended for each company that is willing to understand the factors that have the strongest impact on the development of its business (while at the same time being significant at level 0.05 alpha) and where it could focus to improve its results.

CONCLUSION

This study provides an analysis of the sustainable practices in the logistics sector with a specific focus on the impact on the forestry industry. The overall consensus among actors in this industry regarding the positive effects of sustainability on the development of business is identified. Even though the benefits have been acknowledged, the actual implementation of sustainable practices, such as route optimisation to decrease carbon emissions and practices to reduce waste from operations, is relatively low. In addition, the study has identified the need to improve monitoring of emissions and exercise further moderate efforts to introduce sustainability within the logistics sector in the forestry industry.

REFERENCES

1. Bakalova, R., (2023): Feasibility and economic effectiveness in experimental-statistical research of marine diesel fuels. *STENO Publishing House*, Varna.
2. Deckert, C., (2020): *Sustainable Logistics*, in: Idowu, S., Schmidpeter, R., Capaldi, N., Zu, L., Del Baldo, M., Abreu, R. (Eds.), *Encyclopedia of Sustainable Management*. Springer International Publishing, Cham.
3. Dimitrakiev, D., Dachev, Y., Milev, D., (2020): *Response organization and control strategies during oil spills*. International Journal of Scientific and Technology Research 9, pp.1825–1828.
4. Dimitrakieva, S., Demirova, S., Mehmedov, M., (2023): *Characteristics and peculiarities of marketing and logistics in the management of small and medium-sized enterprises*. Presented at the E3S Web of Conferences. https://doi.org/10/gtnfnw

5. Dimitrakieva, S., Gunes, E., Dimitrakiev, R., Atanasova, C., (2022): *The Role of Digitalization in the Shipbroking Business*. Presented at the Proceedings of the International Association of Maritime Universities Conference.
6. Gancheva, Y., (2021): *Some Problems Related To The Exploitation Of Automated Container Terminals*. Pedagogika 93 (7s): pp. 122–131. https://doi.org/10/grt2tr
7. Kalinova, Z., 2023. Entrepreneurship – a Tool for Renewal and Modernization Of the Educational System. ped 95 (6s): pp.142–154. https://doi.org/10/gtj7fg
8. Kanev, D., (2018): *The Paradox Of Information. Economics and Management*, Faculty of Economics, South-West University "Neofit Rilski" Blagoevgrad 14: pp. 59–73.
9. Kirechev, D., (2017): *Impact of Climate Change on the Development of the Agrarian Sector–Adaptation and Mitigation Measures*. Izvestia Journal of the Union of Scientists-Varna. Economic Sciences Series 1: pp. 111–125.
10. Kirecheva, E., (2022): *Change Management to Overcome Crises by Implementing Management Systems in Organizations.* Journal of the Union of Scientists - Varna 11: pp. 79–87.
11. Letunovska, N., Offei, F.A., Junior, P.A., Lyulyov, O., Pimonenko, T., Kwilinski, A., (2023): *Green Supply Chain Management: The Effect of Procurement Sustainability on Reverse Logistics*. Logistics 7 (47). https://doi.org/10/gtk9n5
12. Luhas, J., (2022): *The interconnections of lock-in mechanisms in the forest-based bioeconomy transition towards sustainability*. Lappeenranta-Lahti University of Tech.
13. Lumivero, 2024. XLSTAT Statistical and data analysis solution. https://www.xlstat.com/en/
14. Mednikarov, B., Kalinov, K., Kanev, D., Madjarova, T., Lutzkanova, S., (2019): *Current trends in the maritime profession and their implications for the maritime education*, in: Proceedings of the International Association of Maritime Universities Conference: pp. 275–286.
15. Narleva, K., Narlev, Y., Gancheva, Y., (2023): *Maritime Education and New Skills in the Digitisation Process*. HR and Technologies: pp.57–72.
16. Palander, T., Vesa, L., (2022): *Data-Driven Optimization of Forestry and Wood Procurement toward Carbon-Neutral Logistics of Forest Industry*. Forests 13 (759).
17. Pauliková, A., Chovancová, J., (2022): *Improving Energy Efficiency Through Energy Management Systems Implementation - A Cluster Analysis Of ISO 50001*. Presented at the 15th International Scientific Conference WoodEMA 2022 - Crisis Management and Safety Foresight in Forest-Based Sector and SMES Operating in the Global Environment: pp. 319–325.
18. Vienažindienė, M., Tamulienė, V., Zaleckienė, J., (2021): *Green Logistics Practices Seeking Development of Sustainability*: Evidence from Lithuanian Transportation and Logistics Companies. Energies: 14 (22) https://doi.org/10/gtk9n3
19. Yotsov, I.V., Dimitrakiev, D.Y., Zaburtov, A., Koritarov, T.D., 2017. *Analysis of the logistics transport corridors i black sea region based on the short sea shipping concept*. Presented at the 18th Annual General Assembly of the International Association of Maritime Universities - Global Perspectives in MET: Towards Sustainable, Green and Integrated Maritime Transport, IAMU 2017, pp. 502–512

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FORESIGHT IN TRADITIONAL SECTORS: APPLICATION OF DELPHI METHOD FOR ANALYSING THE DEVELOPMENT OF INNOVATION POTENTIAL OF SMES IN FURNITURE AND AGRIBUSINESS SECTOR

Teodora Marinova Georgieva, Daniela Ventsislavova Georgieva

Abstract: Agribusiness (agriculture and related value chain activities) is key to the development of a national economy. Technological innovations play a decisive role in the development of the agricultural sector. The success of the implementation of new technologies and the use of their full capacity depends on many factors, the main one of which is the innovation potential of economic entities operating within agribusiness. Innovation potential is determined by the understanding of the importance of innovation, the readiness to implement innovation, the available innovation capacity, and the innovation development practices applied by economic entities (natural and legal entities). The report's purpose is to approve the application of the Delphi method for predicting the development of the innovation potential of economic entities working in agriculture, the forestry sector and the furniture industry.
Keywords: Foresight, Innovation potential, Delphi method, Agribusiness, furniture industry

1. INTRODUCTION

Innovation is one of the most recognizable factors for economic growth and competitiveness (Porter, 1990; Fagerberg et al., 2010). Innovations are sector-specific – such as content, development and implementation process, determinants, and visible and invisible effects. The engines for the success of innovation projects are different, as are the policies that influence, initiate, predetermine, and direct them. This is the reason why the assessment of the innovation potential at the national level logically goes down one level - to its sectoral characteristics. Sectoral differentiation reveals how participants in technological chains and sectoral innovation systems interact in the process of creation, integration and implementation of technological, organizational and marketing innovations. Analyses of sectoral innovation systems in the field of agriculture and furniture industry provide evidence of the essence and importance of the innovation activity of the companies included in them and thus support the creation of sector-based innovation-oriented policies and measures with a real effect on the economy (Improving Innovation Indicators, 2019; Fadhil et al., 2017; Renwick et al., 2014; Leo et al., 2022). Backwards and forward participation of manufacturing companies (in the field of furniture industry and agribusiness for example) in global value chains contributes to enhancing the productivity of countries engaged in such chains (Urata and Baek, 2020). It is suggested to spur productivity growth through various mechanisms such as accessing imported inputs, benefiting from knowledge transfers from multinational corporations, and experiencing competitive pressures from global markets (Criscuolo and Timmis, 2017). GVCs allow multinational corporations (including in the field of furniture industry and agribusiness) to involve suppliers and collaborators from developing and emerging markets to reduce production expenses and sell goods in advanced economies to maximize profits. However, the participation of Bulgarian companies in such chains is of low level due to the risks and shocks throughout the GVCs (Georgieva, 2023).

For the objectives of the present report, the innovation potential is described as the understanding of the importance of innovation, the readiness to implement innovation, the available innovation capacity, and the innovation development practices applied by economic entities (natural and legal furniture and agribusiness entities), which can be distinguished based on geographical, sectoral or another sign. Innovation potential also depends on the regulatory and economic environment and on how economic entities position themselves in relation to it. For forecasting the impact of GVCs on the companies' innovation potential, we proved the application of the Delphi method as a reliable instrument based on expert opinion. The results achieved will be further complemented with data generated through other quantitative and qualitative tools.

2. SURVEY METHODOLOGY, RESULTS AND DISCUSSIONS

2.1. Methodology

The Delphi method is most often used to obtain information from a group of experts belonging to different stakeholder groups (usually based on the "quadruple helix" model – policymakers, business representatives, researchers and representatives of civil society). The information collected usually consists of the opinions of experts on a predetermined topic (Diamond et al., 2014). The Delphi survey is divided into several rounds or stages of data collection. In the past, the Delphi method was used to make predictions, but now it is mainly applied to reach consensus among experts on complex topics. As a rule, the first round is used to gather ideas, suggestions and opinions of the participating experts. To this end, questions are usually open-ended and allow participants to express their opinions in their own words. For this reason, the first round is always the most difficult and requires a significant amount of time and effort from the participants. This inevitably leads to some dropping out of participants and their number always decreases in the second (and third) round. The answers given by the participants in the first round are analysed, arranged and summarized in statements. In the second round, experts are asked to express their agreement with these statements. Their answers are again analysed and presented to the participants in the third round in the form of feedback. The participants are then asked to re-evaluate their answers, taking into account the answers of the other participants in the discussion. This standard methodology was adapted and slightly modified in the present study.

2.2. Research results and discussion

Data collection in the first round took place between 3 and 24 April 2023. The online questionnaire consisted of open and closed questions. They included five demographic questions (age, gender, education, region and professional field) and three thematic sections, each with five questions. The purpose of the first section was to analyse the vision of the experts from the furniture industry and agribusiness regarding the essence of the GVC, as well as the impact of participation in similar chains on the economic development of the regions in which the enterprises participating in the GVC carry out economic activity. Through the questions included in the second section, opinions were sought from the experts regarding the criteria for evaluating the capabilities of furniture and agribusiness firms in global value-added chains to develop their innovative potential. The innovative potential of companies is seen as a driver for their competitiveness and upward development in global chains, as well as a result of their effective participation in them. In this group of questions, question 7 deserves attention: How does the participation of enterprises in GVC affect their innovation potential? and question 13: How can sharing responsibility with other actors in the chain contribute to increasing innovation potential? The experts' proposed answers are presented in Figures 1 and 2. For question 7, 14 statements were formed based on 66 responses from the first round.

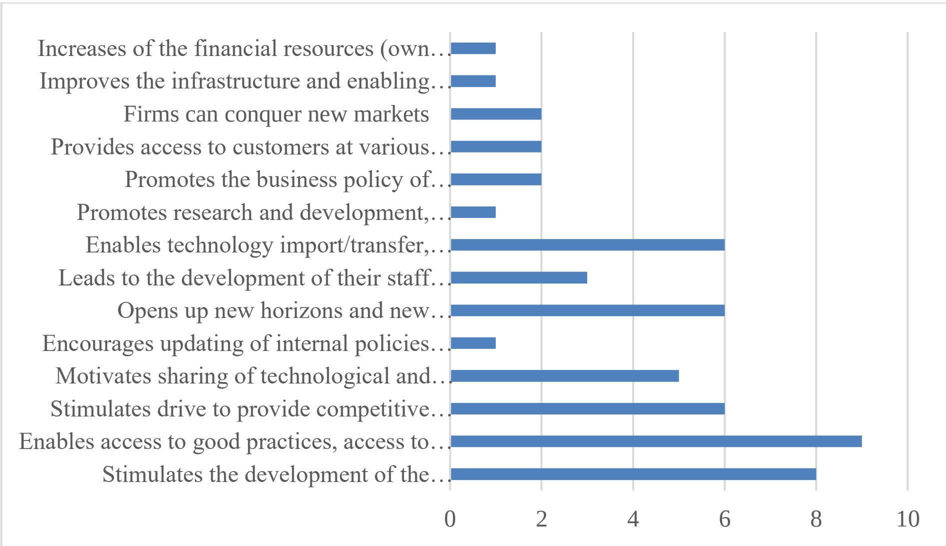

Figure 1. Proposed statements after the first Delphi round on question 7: How does the participation of enterprises in GVC affect their innovation potential?

The experts unanimously approved all 14 in the second stage. Faced with the difficult task of determining the top five in the final round of the survey, the experts split their votes fairly evenly, with only two of the statements garnering greater support (half of the experts). These are:

1. The participation of enterprises in GVC gives them the opportunity to access good practices, access to innovations, borrow experience and obtain know-how.
2. Participation in GVC stimulates the development of the innovative potential of companies through the need to solve non-traditional problems in the process of interaction with foreign partners.
3. For a third of the participants (6), the most important ways in which the participation of enterprises in GVC affects their innovation potential are the following:
4. Participation in GVC stimulates the aspiration to provide competitive products/services.
5. Participation in GVC opens up new horizons and new partnerships.

6. Participation in GVC enables the import/transfer of technology, innovation exchange, technology sharing, knowledge exchange and dissemination of established practices.

The differences between the arrangement in the second and third rounds are minimal. For question 13, 37 responses were received and based on them, 12 statements were proposed to the experts in the second round. They accepted 9 of them and rejected the other three. At the final stage, the experts' votes were fairly evenly distributed. One statement was selected by half (9) of the experts, three statements received 7 votes each, two were nominated by six experts, and the remaining three received 4 votes each.

1. Sharing means the exchange of innovations, knowledge and technologies between the participants in the chain.
2. The mutual search for adequate solutions to reduce the risk of liability.
3. Through technology transfer between global and local companies.
4. By combining efforts for greater efficiency.

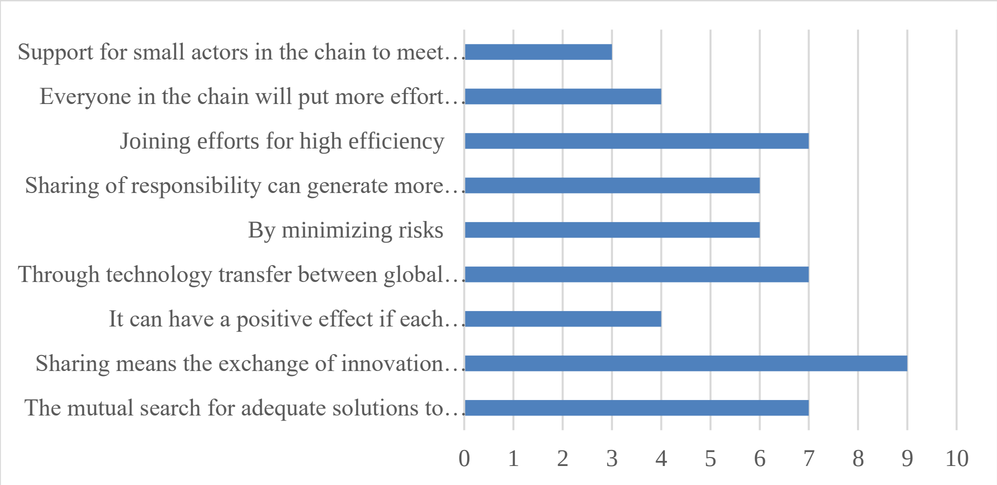

Figure 2. Proposed statements after the first Delphi round on question 13: How can sharing responsibility with other actors in the chain contribute to increasing innovation potential?

The opinion that sharing responsibility goes hand in hand with the exchange of innovation, knowledge and technology, which increases the innovation potential of all actors in the chain, took the highest position in both the second and third rounds. The rest of the statements change their positions but without drastic shifts in the arrangement.

The third section aimed to outline the experts' opinions on European and national policies – their role, implementation and effectiveness – to build the autonomy of the European market from foreign markets and suppliers. The responses received were analysed. Those with similar meanings were merged, some were slightly edited, and others remained unchanged. A total of 600 different answers were received to the 15 questions. After their analysis and summarization, 200 statements were formed, which were included in the questionnaire for the second round. Data collection for the second round took place between 1 and 17 June 2023.

Table 1. Results after the first Delphi round

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No of answers	22	16	12	53	44	20	66	48	35	60	58	55	37	41	33
Statements	8	15	11	16	12	7	14	14	12	20	18	14	12	14	13

The online questionnaire included only closed questions. The second part of the study was based on the results of the first round and aimed at reaching an agreement between the experts on the dimensions of the impact of the activity of global value-added chains on the Bulgarian companies included in them, as well as on the competitiveness of the regions where these are located companies. The questionnaire was again divided into four sections – one demographic and three thematic, each with five questions. For each of the questions in the three thematic sections, a different number of statements (answers) were proposed. The experts expressed their agreement/disagreement with these statements, indicating one possible answer for each of them (Strongly agree/agree; Rather agree/agree; Neutral/neutral; Rather disagree/disagree; Strongly disagree/disagree). Agreement was not sought for three of the questions, but instead, the experts were asked to select the five answers they felt were most important. The purpose of the Delphi study was to reach agreement (consensus) among the experts on the stated statements. Consensus was defined as the percentage of agreement—specifically, consensus was reached if 75% or more of the experts responded that they strongly agreed or rather agreed with the given statement.

Table 2. Results after the second Delphi round

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No of answers	8	15	11	16	12	7	14	14	12	20	18	14	12	14	13
Statements	5	*	*	9	6	6	14	13	12	*	18	12	9	13	1

* in this question, agreement with the statement was not sought, but a selection of the most important statements according to experts

Experts agreed with 118 statements.

Data collection for the third round took place between 11 July and 3 August 2023. As in the second round, the third included only closed-ended questions. The experts were asked to indicate those statements which, in their opinion, are the most important or which best describe the impact of the activity of global value-added chains on the Bulgarian companies included in them, as well as on the competitiveness of the regions where these are located companies. Since such a ranking had already been done for three questions in the second round, there was no point in repeating them and the third questionnaire included only 12 questions. These 12 questions were identical to those in the second round, but participants only chose between the answers (statements) that received over 75% support (agreement) in the second round. Since in the last (15th) question of the second round, only one of the answers passed the 75% agreement threshold, an exception was made for this question and in the third round all answers with at least 65% agreement were added (7 statements in total).

3. CONCLUSIONS AND PRACTICAL IMPLICATIONS

The Delphi method is an interview method with different steps, that has to be performed in written form by experts of different departments Thereby the experts are asked about defined events in future or about upcoming trends. The procedure is based on the individual and intuitive evaluation of experts. The experience gained after the completion of the exercise shows that the key success factors for the Delphi method application are as follows:

- Careful choice of experts of different interrelated fields, who are qualified to make professional evaluations;
- The willingness of the experts for participation during the whole procedure has to be ensured in the run-up;
- A questionnaire has to be prepared, which contains the relevant content and which can be answered by professionals with different backgrounds.

The experts participating in the Delphi survey recognize that engagement in GVCs enhances regional competitiveness and fosters innovation potential of furniture and agriculture companies. They unanimously acknowledge the opportunity companies to access best practices, innovation, experiential learning, and knowledge acquisition. A crucial measure for assessing the potential or capacity for upgrading within global value chains is the innovation undertaken by furniture and agribusiness companies, focusing specifically on collaborative projects for product and process improvement. Although companies and representatives of the regions and government institutions may differently perceive GVCs management and hence employ various strategies to tackle them, there are shared risks that are best mitigated through coordinated efforts. Such actions are already under consideration by OECD and other organizations. They are primarily focused on identifying the spectrum of possible threats, mapping both local and international participants engaged in critical chains, prioritizing the transport of essential goods, streamlining procedures for essential activities, facilitating investment and operational permits, and extending certification processes to promote production, etc. Such strategies will impact both the furniture industry and agriculture. Hence more analyzes on that matter are needed.

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REFERENCES

1. Criscuolo, C., Timmis, J. (2017): *The relationship between global value chains and productivity*. International Productivity Monitor (32): pp. 61–83
2. Diamond, I. R., Grant, R. C., Feldman, B. M., Pencharz, P. B., Ling, S. C., Moore, A. M., Wales, P. W. (2014): *Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies*. Journal of Clinical Epidemiology, 67(4): pp. 401-409. https://doi.org/10.1016/j.jclinepi.2013.12.002
3. Fadhil, R, Maarif, M., Bantacut, T., Hermawan, A. (2017): *Assessment of Innovation Potential of Gayo Coffee Agroindustry.* Quality Innovation Prosperity, 21(3), 114–126. https://doi.org/10.12776/qip.v21i3.888
4. Fagerberg, J., Srholec, M., Verspagen, B. (2010): *Innovation and Economic Development*, Handbook of the Economics of Innovation, vol. 2, pp 833-872
5. Georgieva, D. V. (2023): Predizvikatelstva pred uchastieto na inovativni balgarski predpriyatia v globalnite verigi na stoynostta, Tendentsii i strategii za vazstanovyavane na ikonomicheskata i obshtestvenata sistema sled pandemiyata ot Covid-19, Izdatelski Kompleks – UNSS, pp. 337-346
6. Improving Innovation Indicators: Better Data to Track Innovation in Australia (2019):, Australian Government, Department of Industry, Innovation and Science, ISBN: 978-1-922125-65-1
7. Leo, R., Camboim, G., Silva Avila, A., Reicherta, F., Zawislak, P. (2022): *Innovation capabilities in agribusiness: evidence from Brazil*, RAUSP Management Journal. (57)1: 65-83. DOI 10.1108/RAUSP-02-2021-0019.
8. Porter, M. E. (1990): *The Competitive Advantage of Nations*. Competitive Intelligence Review, (1):14. http://dx.doi.org/10.1002/cir.3880010112.
9. Renwick, A., Läpple, D., O'Malley, A., Thorne, F. (2014): Innovation in the Irish Agrifood Sector.
10. Urata, S., Baek, Y. (2020): *The Determinants of Participation in Global Value Chains: A Cross-Country, Firm-Level Analysis*. ADBI Working Paper 1116. Tokyo: Asian Development Bank Institute. Available: https://www.adb.org/publications/determinants-participation-globalvalue-chains

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RESEARCHERS' EXCELLENCE NETWORK

AI IN FORESTRY – A COST-BENEFIT ANALYSIS

Maya Ivanova

Abstract: Technologies and AI have proliferated in almost every sector, including the forestry industry. The current paper explores the application of AI along the entire supply chain of forestry and makes a detailed cost-benefit analysis. The study steps on secondary sources and literature research but also examines valuable examples of real cases and companies that belong to the forest sector and apply AI in their business. The cost-benefit analysis encompasses each level of the supply chain and provides the perspectives of all involved stakeholders.
Keywords: AI, forestry

1. INTRODUCTION

Forestry science primarily focuses on two main areas corresponding to the wood supply chain's segments (D'Amours et al, 2008): 1) forest management, harvesting, storage and transportation, and 2) processing, production, distribution and sales of wooden products (D'Amours et al, 2008). The latter, being more aligned with industrial processes, extensively incorporates high technologies, including artificial intelligence (AI), as documented in numerous studies (Molinaro & Orzes, 2022). In contrast, the former segment, characterized by its reliance on human decision-making and manual labour, has seen less emphasis on technology and AI applications. Therefore, this paper aims to highlight the main applications of AI in the forestry industry, particularly related to forest management, harvesting, storage and transportation. It will also provide a cost-benefit analysis to underpin further research and support decision-makers.

Following an overview of the forestry supply chain, the paper will define AI and its role in forestry, together with particular examples. It will finish with a deeper cost-benefit analysis to outline the main challenges and opportunities.

2. FORESTRY INDUSTRY SUPPLY CHAIN

Forestry is the science of planting and taking care of large areas of trees (Cambridge Dictionary, https://dictionary.cambridge.org/dictionary/english/forestry). In terms of economy, this is the industry managing extensive tree populations and is vital for both wood production and ecological balance. In this regard, the forestry industry covers the first levels of the wood supply chain, that is encompassing all processes of maintenance of wood resources and converting them into raw wooden material, i.e. Forest management and protection, Harvesting, and Storage and transportation (see Fig. 1).

Forest management is the ground stage, which includes activities for general maintenance of the forests, thus guaranteeing high-quality resources for the subsequent stages (D'Amours et al, 2008), as well as the sustainable long-term performance of the forests as eco-systems. Those activities comprise estimation of the biomass and potential for future use, data collection of forest attributes like wood species, other flora and fauna representatives, age, soil, plantation management, and overall evaluation and analysis of the forest. Forest protection plays a major part in forest management (Molinaro & Orzes, 2022), because of its direct links to sustainable management and data analysis. Detection and ability to forecast fires or other force majeure situations (e.g. insects or diseases on the trees) are processes, related both to environmental science and the wood industry.

The next level of the forestry supply chain is Harvesting – a fundamental process, which extracts the raw material to start its journey along the rest production stages (Zhang et al, 2020). The provision of good quality timber requires precise selection of the most appropriate trees, felling, debranching and bucking into logs of specific dimensions and types. All those activities rely heavily on people with specific roles and skills to implement the tasks (D'Amours et al, 2008). Additionally, the process is time-consuming and is related to physical allocation and movement.

Finally, Storage and transportation are the link between the forestry part to the manufactural stages of the wood supply chain, where the raw materials are first identified and marked, according to their characteristics (species, size, quality, etc.) and later distributed and delivered to the next level producers (sawmills, pulp production, bioproducts, residues, etc.) (Zhang et al, 2020). A crucial point in this process is the optimal organization and coordination among the participants, to ensure a smooth and even delivery, minimise costs and improve efficiency (Mueller et al, 2019).

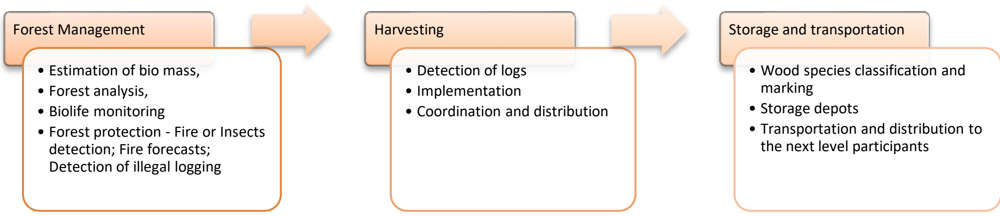

Figure 1. Forestry supply chain

3. AI AS A PHENOMENON

In recent years AI has become very popular far beyond the narrow technological industries. Its ambiguous nature provoked an intense debate on formulating a precise definition. Artificial intelligence, or AI, is a technology that enables computers and machines to simulate human intelligence and problem-solving capabilities (IBM, 2023). Since it is often combined with sensors, robotics, specialized software systems, etc. AI can perform (semi)independently a lot of tasks, traditionally implemented by people, thus minimising human intervention and revolutionizing many industries in terms of efficiency and productivity. AI is based on algorithms, modelled to use neural networks to self-educate in the process of operation. AI has proliferated largely in different industries in very diverse forms, which made AI a universal complementary tool for employees. Many AI algorithms encompass enormous sets of data to enable deeper processing and analysis that would be impossible for humans to do. Generative AI, on the other side, stepping on natural language processing and large language models can synthesize text, images, video, software code, and even molecular structures (IBM, 2023).

The rapid development of AI is driven by various factors like quantity and quality of information and data, collected at any point in any industry, synergetic use of technologies from different types and classes like satellite imagery, video, any type of sensors, raw data of technical, social and biological metrics.

The forestry industry generates a lot of data along the supply chain, which could be easily utilized by AI to extract relevant information and improve the sector (Zhang et al, 2020). Moreover, AI can successfully be used to assist foresters in their traditional activities, e.g. physically walking through forest terrain to record metrics or collect data from the forest (Peng & Sadaghiani, 2023).

4. AI APPLICATION ALONG THE FORESTRY SUPPLY CHAIN

Wood is hardly comparable to other resources (e.g. aluminium, plastics, steel, etc.), because the wood characteristics may differ according to wood species, types, and even within them (Molinaro & Orzes, 2022). This requires a lot of more specific data to be collected, kept and utilized within the sector, to select and use the most appropriate chunk of raw wood material for the relevant product (e.g. lumber, pulp or furniture). The AI applications are based on huge sets of input data, like forest characteristics, resources, energy, materials and social components. The synergetic effect of combining the entire raw data, collected along the forestry supply chain can serve as a source for meaningful and insightful output, derived with the assistance of AI-based systems (Zhang et al, 2020).

4.1. Forest management

Recent years evidenced the great popularity and use of sensor and imagery technologies in forestry (Mueller et al, 2019). The constantly collected data allows for further and more precise analytics and forecasts. Although it was also possible before the AI age, nowadays the amount of data is enormous and with the assistance of AI, it is possible to translate the observed objects into forest attributes.

Monitoring forests by drones or cameras with integrated AI (Buchelt et al. 2024) provides significant data on the forest inventory, which facilitates the estimation of the industrial potential of the wood (e.g. height, bark volume, biomass, wood density, diameter). The ecological aspect of AI analysis of the forests (e.g. *tree life and mortality predictions, species classification, forest coverage mapping, forest loss mapping and burned areas estimation*) contributes to informed decision-making and enhanced sustainable approach in forest management (Peng & Sadaghiani, 2023). Moreover, by using aerial images, AI can make *measurements of carbon, biomass, moisture content, temperature*, etc., thus creating a full overview at the forest level. The latter is especially useful for forest protection from disasters like fires or insects and diseases (Kinaneva et al, 2019) – AI algorithms can *identify certain patterns of images, weather parameters or sounds detection to alarm about such cases*, or even *predict their occurrence* (Molinaro & Ordez, 2022). Last, but not least, protection against illegal logging is another benefit from the AI processing and analysis of images or acoustic sounds.

4.2. Harvesting

The process of selecting, felling, cutting and sorting trees is still implemented manually, because of the more complex combinations of physical and intellectual activities. Therefore, human presence in those activities is still mandatory, even with remote control, e.g. *robotised machines can easily approach inaccessible areas*, but are always under the full control of a human operator (Boitsov et al., 2021). Yet, AI could be helpful in terms of *organization,* *communication and coordination to improve the efficiency* of the harvesting groups and methods (Proto et al, 2020).

4.3. Storage and transportation

Before delivery to the next-level participants, raw wood material undergoes rough characteristics estimation like *identification of wood species, moisture, pulp properties, knot detection (Verly Lopes et al, 2020), quality*, etc. According to this classification and marking, the logs are stored and distributed differently. AI algorithms identify much faster the timber and are even able to *propose the most suitable storage depot to keep the timber in the best conditions*, thus saving costs and time (Peng & Sadaghiani, 2023).

Transportation of the raw wood material depends on the various vehicles and possible routes, so the AI can *optimize them both* but also consider other factors like speed, weather, traffic conditions, etc. (Peng & Sadaghiani, 2023).

Many companies already use intensely AI in their operations and share valuable insights from their experiences and innovative solutions. For instance, ByteLake has developed an AI-powered method for counting trees using drones, providing accurate and efficient forest inventory management that greatly reduces the time and manpower traditionally required for such tasks (URL: https://www.bytelake.com/en/case-studies/case-study-counting-trees-with-drones). Collective Crunch, on the other hand, leverages AI in its platform to analyze climate data, soil information, and satellite imagery to offer precise forest analytics, thus enabling better forest management and carbon footprint monitoring (URL: https://www.collectivecrunch.com/product). Forestry AI focuses on automating the detection of forest changes and threats, such as illegal logging or disease outbreaks, by analyzing satellite images with AI algorithms (URL: https://forestryai.website). Rainforest Connection transforms old smartphones into powerful guardians of the rainforest; by deploying them as acoustic monitors high in tree canopies, they can detect and alert authorities to the sounds of illegal logging in real time (URL: https://rfcx.org). Rezatec applies geospatial AI to provide detailed insights into forest health, growth patterns, and risk assessment, helping foresters make informed decisions on forest conservation and resource allocation (URL: https://www.rezatec.com). Each of these examples underscores the diverse potential of AI in enhancing the sustainability, productivity, and protection of forest resources globally.

5. COST-BENEFIT ANALYSIS OF AI APPLICATION IN FORESTRY

The technology debate has attracted a lot of enthusiasts and sceptics regarding the application of AI in forestry. In this regard, it would be much more useful for decision-makers to weigh the advantages and disadvantages, before making a final choice.

Estimation of the cost and benefits of the AI application in forestry could be explored in two perspectives – micro and macro context. Micro context represents the potential pros and cons for the companies and institutions directly dealing with forest management, harvesting, storage and transportation. These are mostly business-oriented effects, considering the four functional areas (operations, marketing, finance and HRM). The other analysed perspective affects the macro level, i.e. the region, country, or the entire sector. In this group, there will be mostly registered environmental, social, legal, political and technological aspects, which are less controllable, but also slower in terms of visibility and aggregated impact. Table 1 presents the most important points of costs and benefits of the AI application in forestry.

The micro-level benefits and costs affect mostly company performance and personnel, because of the close correlation between technology and labour costs. The need for skilful and specially educated employees appears on both micro and macro levels, which is a prerequisite for long-term planning of the educational and training programmes. In a macro context, the environmental benefits prevail, ensured by the numerous opportunities for more sustainable forest management.

While at the company level, the positive impacts of AI are connected with higher efficiency and productivity, at one point the urge towards maximizing efficiency might disrupt the ecological balance and biodiversity. Thus, a micro-level activity might have a macro influence.

Table 1. Cost-benefit analysis of AI in forestry at the micro and macro level

	Benefits	**Costs**
Micro level	✓ Improved efficiency of forest management ✓ Improved efficiency of transportation and distribution ✓ Saving labour costs for manual tasks ✓ Distant monitoring, allowing for savings on transportation and access to the forests ✓ Contributes to provision of constant quality of the wood	✓ Labour costs for specialized skilful personnel to operate and maintain the AI technologies ✓ Huge initial capital investment ✓ Maintenance costs for the AI technologies ✓ Constant need to update and upgrade the AI technologies ✓ Less efficiency if applied only partially, or overlapping with manual processes ✓ Employee resistance, leading to undesirable issues (e.g. strikes, leakage of people, etc.)
Macro level	✓ Huge environmental positives for sustainable forest management ✓ Prevention and early forecast of force majeure cases like fires, insects, etc. ✓ Less disruption/disturbing of forest flora and fauna (because technologies operate from a distance, no need for humans to walk through the forest) ✓ Prevention of illegal felling and timber traffic	✓ Use of drone observation may raise privacy concerns for the communities, living in those areas ✓ Over-optimization of efficiency leading to disruption of ecological balance ✓ Need for skilful, educated employees, who can work with AI and other technologies, and are still competent in forest management ✓ Unemployment, loss of jobs

6. CONCLUSION

The integration of AI within the forestry supply chain offers transformative potential, enhancing sustainability and operational efficiency. A careful consideration of the associated costs and benefits will be crucial for harnessing AI's full potential in fostering a sustainable and productive forestry industry, considering also the well-being of the workers in the forestry industry.

Technologies could be very helpful as complementary tools to humans in their work and evaluation of the wood. Examination of technology proliferation in the wood industry might delve in both directions – along the processes and tasks within them, as well as exploring each technology feature that would be possible to use in any of the stages of the wood supply chain.

REFERENCES

1. Boitsov, A., Vagizov, M., Istomin, E., Aksenova, A., & Pavlov, V. (2021). Robotic systems in forestry. In IOP Conference Series: *Earth and Environmental Science* (Vol. 806, No. 1, p. 012034). IOP Publishing.
2. Buchelt, A., Adrowitzer, A., Kieseberg, P., Gollob, C., Nothdurft, A., Eresheim, S., ... & Holzinger, A. (2024). Exploring artificial intelligence for applications of drones in forest ecology and management. *Forest Ecology and Management*, 551, 121530.
3. D'amours, S., Rönnqvist, M., & Weintraub, A. (2008). Using operational research for supply chain planning in the forest products industry. *INFOR: information systems and operational research*, 46(4), 265-281.
4. IBM (2023). What is artificial intelligence (AI)? Retrieved from: https://www.ibm.com/topics/artificial-intelligence
5. Kinaneva, D., Hristov, G., Raychev, J., & Zahariev, P. (2019, May). Early forest fire detection using drones and artificial intelligence. In 2019 42nd International Convention on *Information and Communication Technology, Electronics and Microelectronics (MIPRO)* (pp. 1060-1065). IEEE.
6. Molinaro, M., & Orzes, G. (2022). From forest to finished products: The contribution of Industry 4.0 technologies to the wood sector. *Computers in Industry*, 138, 103637.
7. Müller, F., Jaeger, D., & Hanewinkel, M. (2019). Digitization in wood supply–A review on how Industry 4.0 will change the forest value chain. *Computers and Electronics in Agriculture*, 162, 206-218.
8. Peng, W., & Sadaghiani, O. K. (2023). Enhancement of quality and quantity of woody biomass produced in forests using machine learning algorithms. *Biomass and Bioenergy*, 175, 106884.
9. Proto, A. R., Sperandio, G., Costa, C., Maesano, M., Antonucci, F., Macrì, G., ... & Zimbalatti, G. (2020). A three-step neural network artificial intelligence modeling approach for time, productivity and costs prediction: A case study in Italian forestry. *Croatian Journal of Forest Engineering: Journal for Theory and Application of Forestry Engineering*, 41(1), 35-47.
10. Verly Lopes Jr, D., Bobadilha, G. D. S., & Grebner, K. M. (2020). A fast and robust artificial intelligence technique for wood knot detection. BioResources, 15(4), 9351.
11. Zhang, X., Wang, J., Vance, J., Wang, Y., Wu, J., & Hartley, D. (2020). Data analytics for enhancement of forest and biomass supply chain management. *Current forestry reports*, 6, 129-142.
12. ByteLake. URL: https://www.bytelake.com/en/case-studies/case-study-counting-trees-with-drones
13. Cambridge dictionary, https://dictionary.cambridge.org/dictionary/english/forestry
14. Collective crunch. URL: https://www.collectivecrunch.com/product
15. Forestry AI. URL: https://forestryai.website
16. Rainforest Connection. URL: https://rfcx.org
17. Rezatec. URL: https://www.rezatec.com

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ACHIEVING INNOVATIVENESS THROUGH PARTICIPATION IN GLOBAL VALUE CHAINS: VIEWS OF MANAGERS OF BULGARIAN FURNITURE ENTERPRISES

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Abstract: Global value chains (GVCs) are a driver of economic transformation and growth of local economies. They are a channel for the dissemination of technological knowledge, entrepreneurial culture and innovation capacity. Global leaders can create opportunities for local producers to improve their position in the supply chain. A large part of Bulgarian enterprises do not participate in such chains. Presently, with Western markets experiencing stagnation, anticipations arise for disruptions within the Bulgarian furniture industry, likely to exert a substantial impact on the GVCs and hence on their innovativeness. The paper aims to outline the current state, trends and challenges ahead of the Bulgarian furniture enterprises, related to achieving innovativeness through participation in GVCs. It is done through a survey of managerial vision and opinion related to achieving innovativeness through participation in such chains. Data from online questionaries distributed among managers of Bulgarian furniture companies between November 2023 and February 2024 is presented. The study of statistical relationships and dependencies is based on the Chi-square test with the program IBM – SPSS Statistics. The study supports the literature concerning the involvement of furniture companies in GVCs.
Keywords: global value chain, innovation, furniture enterprises, questionaries

1. INTRODUCTION

The companies engaged in global trade and manufacturing are progressively developing through participation in GVCs. These chains encompass all the tasks undertaken by companies and employees to take a product from its inception through production to its utilization and eventual disposal (Gereffi & Fernandez-Stark, 2011). Criscuolo and Timmis (2017) argue that participation in GVCs benefits companies by focusing on specialization in the core business activities and offshoring of other activities. This approach involves importing foreign products that are either lower in cost or of superior quality, generating competitive influences within domestic markets, and fostering knowledge diffusion facilitated by multinational corporations (MNCs). Advancements in technology, cost factors, resource and market accessibility, as well as trade policies, contribute to the geographical division of production processes globally based on the competitive advantages of specific locations. This worldwide fragmentation of production is a significant driver of efficiency and enhances the competitiveness of businesses. The ongoing advancement and innovation within the value chain have become essential due to the broadening array of product categories. This is a direct result of the escalating intensity of global competition, the shortened lifespan of products, and the emergence of entry barriers in certain industries. Through innovations, companies can strategically position themselves, gaining both pricing and competitive advantages within a particular chain or network. Value creation is not confined solely to "high-end" activities such as design or branding but it can occur at any stage within the chain (Abonyi, G., 2006, p. 16-21). The furniture industry represents a global business characterized by an extensive and intricate value chain consisting of numerous consecutive phases. Each phase of value-adding requires supporting products and services (Epede & Wang, 2022). Tasks within the furniture value chain range from production activities, which are adaptable and can be executed anywhere by any participant in the chain, to retailing activities, which, in contrast, are restricted and can only occur within the country of the ultimate target market (Kaplinsky et al., 2003). The global furniture industry is experiencing heightened global competition, marked by numerous middle-income countries ascending to stronger competitive positions. High-income countries, which previously held dominance in this sector, are encountering challenges in sustaining their competitive edge. The primary challenge facing companies involved in the global furniture market is imperative to consistently enhance their capabilities by transitioning towards higher value-added activities (Epede & Wang, 2022). Bulgarian furniture firms have yet to fully capitalize on global value chains as a primary catalyst for innovation. Their involvement in the GVC remains limited and largely revolves around collaborating with foreign material suppliers (Georgieva et al., 2023).

The main author hypothesizes is that there are no sufficient managerial practices in terms of participation in GVCs by Bulgarian furniture enterprises due to (1) a lack of understanding of the benefits for the company's competitiveness and (2) fear of being dependent on MNCs. The primary purpose of the paper is to study the managerial point of view related to the risks and benefits of the participation of Bulgarian furniture enterprises in GVCs and the development of innovation and innovation collaboration with external stakeholders as factors for participating in such chains. Subject under analysis are furniture companies' managers who have worked at the firm for at least 2 years and have an understanding of innovation and GVCs participation. The applied research methods are based on the logical, deductive and comparative methods, content analysis and synthesis of specialized literature texts. Data from an author's questionnaire survey conducted among furniture companies in Bulgaria reveals that they do not dependent on GVCs for achieving innovativeness even though they see it as a factor for new partnerships, transfer of knowledge and cost reduction.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

GVCs have three dimensions: (1) structure of input-output flows; (2) territorial (spatial) dispersion; (3) management structure. Without belittling the importance of the three structures an object of further analysis is the managerial dimension in which three main types of GVCs can be outlined - production-related; customer-driven and multi-polar (Abonyi, G., 2006, p. 11-12). In the furniture industry, the value chain is buyer-driven. This signifies that major retailers, marketers, and manufacturers hold crucial positions in establishing decentralized production networks. Consequently, their influence significantly shapes the enhancement patterns of other participants involved in the chain (Epede & Wang, 2022). Having a capacity for innovation is important for enhanced involvement in the GVCs, which contributes to economic development (Fagerberg et al., 2018). Outsourcing certain production activities fosters innovation development, enabling leading firms to streamline costs and allocate more resources to R&D (Vivek et al., 2009). Consequently, companies gain access to new knowledge, concepts, and technology transfers, fostering innovation. Due to the pressures of globalization, national and regional economies are directing efforts towards enhancing their competitive positions within the GVC by prioritizing investments in scientific research and innovation. Companies within the furniture industry are required to make substantial investments in capital, technology, and human resources to manage diverse production stages effectively. Continuous adaptation to evolving consumer trends necessitates ongoing innovation efforts, consuming significant resources in the process (Phuoc et al., 2023, p. 3). Therefore, a subject to analysis is the impact of the GVCs' participation in Bulgarian furniture companies over their innovativeness. To address this goal, the following hypothesis is formulated: *(H1) There is a statistically significant relationship between participation in GVCs and the development of innovation with higher added value*. The furniture industry holds substantial potential for innovation growth, particularly through network participation and collaboration with other stakeholders which allows firms to foster innovation (Hatzichronoglou, T., 1997). Collaboration with entities within the surrounding business environment can improve the innovativeness of the industry by offering better fundamental research, skilled human resources, facilitating knowledge transfer, and conducting training programs. These elements collectively contribute to the development and growth of the furniture sector (Beer, P., 2013 cited in Ratajczak-Mrozek & Herbeć, 2014). Considering this the second hypothesis is as follows: (*H2) There is a statistical relationship between the innovation collaboration of the furniture enterprises with other stakeholders and the participation in GVCs*.

For small businesses situated in less developed countries, like Bulgaria, engaging in GVCs serves as a method to acquire insights into the demands of global markets and facilitates entry into them (Pietrobelli & Rabellotti, 2006, p.9). GVCs' participation provides access to imported products, diffusion of knowledge and positive effects of global competition (Criscuolo & Timmis, 2017), positive effects on employment (Lopez-Gonzalez, 2016), and increasing sectoral added value (Kummritz et al. 2017). GVCs offer new prospects for smaller firms in developing and emerging market economies as companies are not compelled to manage independently every stage of the production processes to engage in the global economy and hence they do not need to oversee all the complexities of the production chain. According to Humphrey and Schmitz (2002), companies engaging in GVCs can create process innovation which reduces the cost of manufacturing by enhancing efficiency in converting inputs and resources into the final output. Firms can develop product innovation with higher quality, which can benefit their market positioning. By developing organizational innovations furniture companies can improve their organizational structures or processes to enhance the value derived from human labor, potentially increasing productivity or effectiveness. Engaging in GVCs enables companies to diversify their product portfolio by entering into intensive and high-tech industries, broadening their range of offerings and market presence. Rodrik (2013) contends that firms engaged in GVCs tend to excel in assimilating advanced technologies but might not experience the same level of success in labor recruitment. In contrast, Baldwin (2014) suggests that GVCs enable access to global markets for manufactured goods, initially leading to a rapid boost in productivity and employment. However, it may underestimate industrialization and capacity building which in the long term, might lead to development stagnation. The Bulgarian furniture industry relies on exports, making it susceptible to disruptions in external markets. Hence, some risks related to GVCs participation can affect the managerial decision of such participation. A drawback of participating in GVCs, in contrast to the local value chains, is the augmented expenses which stem from higher transportation expenses, extended delivery durations, increased intricacy, and a propensity for further amplifying operational expenses, especially for distant destinations (Strange, R., 2020). Gereffi (2013, p. 10) emphasizes that export-oriented industrialization does not guarantee a successful economic development. Hence, the sectors that are relatively productive and integrated into

GVCs often do not contribute significantly to the local economy. The spillover effects, or the positive externalities and impacts on other local sectors, tend to be minimal. Moreover, there exist structural tensions between the central company (focal firm) and the networks of supplier firms within these chains. This can lead to imbalances that are disadvantageous, particularly towards the lower-value-added segments of the chain (Kano et al, 2020).

3. SURVEY METHODOLOGY, RESULTS AND DISCUSSIONS

An online survey among managers of Bulgarian furniture enterprises was conducted, covering the period November 2023 - February 2024. The final questionnaire was filled in by 106 respondents and it consisted of 3 main groups of questions: (1) socio-demographic questions; (2) questions related to the innovativeness of the company and its added value; (3) questions related to GVCs participation and cooperation with external stakeholders. The main goal of the survey is to address the above hypotheses as well as to outline the risks and opportunities to achieve innovativeness through GVCs participation from the managerial point of view. IBM – SPSS Statistics, ver. 19 is used to analyze the collected data. The study of statistical relationships and dependencies is based on the Chi-square test. From a socio-demographic point of view around 42% of the respondents are founders and the rest are representatives of the management departments of the furniture enterprises. 83% are presenting companies that operated in cities while 17% are from small villages. The main market for 2.8% of the enterprises is local (no more than 30 km from their factories), 68% sell only in the territory of the country while 29,2% are focused in the international market as well. From those selling abroad primarily targeted markets are Germany (38,7%); Romania (18,7%); France (9,7%); Greece, Italy and Austria (6,5%). The majority of the surveyed managers see participation in GVCs as leading to positive effects such as the use of cheaper resources (17,9%); conquering new markets (12,3%); new partnerships (12,3%); exchange of knowledge and dissemination of established practices (11,3%); sharing technological and other innovations (9,4%) and access to customers (9,4%). Still, only 34,9% consider that their company participate in GVCs. Around 95% of the surveyed companies have introduced new or improved products or services during the last 12 months before the survey. However, only 15% of them have developed those innovations in collaboration with external stakeholders. Even though the rest claim that they have developed the innovation by themselves only 17% state that the company have an R&D department. In those departments, the majority of the employed personnel (33,3%) is up to 2 staff members. Around 20% claim that they have R&D expenses of which around 32% report them to the National Statistical Institute. The main obstacles to the development of innovation were stated to be: high economic risk and instability (20%); high costs for R&D (17%); lack of sources of funding (13%); lack of qualified staff (10%); presence of undertakings dominating the market (5%); lack of information about the markets (6%); Lack of specific regulatory framework for promoting innovation (4%). 70,8% of the respondents do not think that participation in GVCs can lead to the development of innovation with higher added value to the company. However, when testing the author's hypothesis and based on the analysis of the collected data (see Table 1) it is confirmed the existence of a weak statistical relationship between participation in GVCs and the development of innovation with higher added value. All conditions for the Chi-square test application are fulfilled but the significance level is 0,415, therefore, it is statistically insignificant. Around 69% of the respondents claim that they do not have any contracts for innovation collaboration. Of the rest (31%), around 2% have such contracts with other enterprises from the same industry, 8% - with enterprises from other industries, 14% - with suppliers, 3% - with multinational corporations, 2% - with research institutions and universities, 2% - with consulting agencies. The calculations based on the provided data prove a weak (but insignificant) statistical relationship between the participation in GVCs and the innovation collaboration of the furniture enterprises with other stakeholders (H2, see Table 1).

Table 1. Chi-square tests and Symmetric measures data

Hypothesis	Pearson Chi-Square value	Level of significance	Degree of freedom	Asymp. Sig. (2-sided)	Cramer's V value	Approx. Sig.
(H1)	0,665	α=0.05	n=1	,415	,079	,415
(H2)	0,425	α=0.05	n=1	,515	,063	,515

Source: own calculations, n=106.

If we check the level of statistical relationships between the different types of collaboration that the studied furniture enterprises have and their participation in GVCs, there is evidence of weak statistical relationship between: (1) innovation collaboration contracts with other enterprises from the same industry and participation in GVCs (Cramer's V: 0.189, $p<0.05$); (2) the innovation collaboration contracts with enterprises from other industries and participation in GVCs (Cramer's V: 0.090, $p<0.05$); (3) innovation collaboration contracts with suppliers and participation in GVCs (Cramer's V: 0.043, $p<0.05$); (4) innovation collaboration contracts with multinational corporations and participation in GVCs (Cramer's V: 0.125, $p<0.05$); (5) innovation collaboration contracts with research institutions and universities and participation in GVCs (Cramer's V: 0.102, $p<0.05$); and (6) of innovation collaboration contracts with consulting agencies and participation in GVCs (Cramer's V: 0.010, $p<0.05$). From all those cases only for the third one the conditions for the Chi-square test application are fulfilled meaning that for the other cases, we should be skeptical when accepting statistical relationships.

4. CONCLUSIONS

The analysis of the collected data from Bulgarian furniture enterprises confirms that there is a statistical relationship between the participation in GVCs and (1) the development of innovation with higher added value and (2) the innovation collaboration of the furniture enterprises with other stakeholders. Still, the majority of the surveyed manager do not consider GVCs as factors that improve their company's innovativeness. Even understanding the benefits of participation in GVCs the managers refrain from such considering the main risks as dependence on other companies, restriction of freedom of decision-making and delay in delivery which can negatively affect the R&D and innovation development in furniture companies. This data supports the studies of Strange, R. (2020). In addition, the surveyed managers state that Bulgarian enterprises do not know how to manage the risks of GVCs (24,5%) and hence the managerial practices are influenced by the impact of other participants (29,2%) or are involved in such chains only if a foreign investor requires it (9,4%). There is a lack of managerial understanding of the essence of GVCs (13,2%) and because of the low level of participation in such chains, the competencies of management teams are limited (3,8%).

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REFERENCES

1. Abonyi, G. (2006): Linking Greater Mekong Subregion Enterprises to International Markets: The Role of Global Value Chains, International Production Networks and Enterprise Clusters, United Nations publication, ISBN 13: 978-92-1-120492-6.
2. Baldwin, R. (2014): Trade and industrialization after globalization's second unbundling: How building and joining a supply chain are different and why it matters, DOI 10.3386/w17716.
3. Beer, P. (2013): Naszym „produktem" jest absolwent. Rozm. przepr. Meble News. cited in: Ratajczak-Mrozek, M.; Herbeć, M. (2014): *Furniture companies cooperation and their innovativeness – industrial network approach*. Annals of Warsaw University of Life Sciences, 2014(85):81-94.
4. Criscuolo, C.; Timmis, J. (2017): *The relationship between global value chains and productivity*. International Productivity Monitor, (32): 61–83.
5. Epede, M. B.; Wang, D. (2022): *Competitiveness and upgrading in global value chains: A multiple-country analysis of the wooden furniture industry*, Forest Policy and Economics, Volume 140, issue C, DOI: 10.1016/j.forpol.2022.102737.
6. Fagerberg, J.; Lundvall, B. Å.; Srholec, M. (2018): *Global value chains, national innovation systems and economic development*. The European Journal of Development Research. 30(3): 533–556. doi.10.1057/s41287-018-0147-2.
7. Georgieva, D.V.; Neykov, N.; Barčić, A.P.; Ćurić, P.; Klarić, K. (2023). *Participation of Bulgarian Furniture Manufacturing in Global and Local Value Chains as a Factor Supporting Their Innovation Activities*, Sustainability, 15(17):13260, pp.1-15.
8. Gereffi, G. (2013): *Global value chains in a post-Washington Consensus World*. Review of International Political Economy, 1–29. https://doi.org/10.1080/09692290.2012.756414.
9. Gereffi, G.; Fernandez-Stark, K. (2016): Global Value Chain Analysis: A Primer. Durham, Duke Center on Globalization, Governance & Competitiveness.
10. Hatzichronoglou, T. (1997): Revision of the High-Technology Sector and Product Classification, OECD Science, Technology and Industry Working Papers [1997/02].
11. Humphrey, J.; Schmitz, H. (2002): *How does insertion in global value chains affect upgrading in industrial clusters?*, Regional Studies, 36(9): 1017–1027.
12. Kano, L.; Tsang, E W; Yeung, H.W.-C. (2020): *Global value chains: A review of the multi-disciplinary literature.* Journal of International Business Studies, 51 (2020): 577-622.
13. Kaplinsky, R.; Memedovic, O.; Morris, M.; Readman, J. (2003): The global wood furniture value chain: what prospects for upgrading by developing countries, UNIDO Sectoral Studies Series Working Paper, http://dx.doi.org/10.2139/ssrn.420080.
14. Kummritz, V.; Taglioni, D.; Winkler, D. (2017): Economic upgrading through global value chain participation: Which policies increase the value added gains? (World Bank Policy Research Working Paper 8007). Washington, DC: The World Bank.
15. Lopez-Gonzalez, J. (2016): Using foreign factors to enhance domestic export performance: A focus on Southeast Asia (OECD Trade Policy Papers, No. 191). Paris: OECD Publishing.

16. Phuoc, D.M.; Tai, D. Q.; Phuong, V.H.; Tung, V.V.; Hung, T.X. (2023): *Product Innovation Among Furniture Firms: The Case of the Private Economy Area*. Journal of Law and Sustainable Development, 11(11):e1648, pp. 01-17, DOI: 10.55908/sdgs.v11i11.1648.
17. Pietrobelli, C.; Rabellotti, R. (2006): Clusters and Value Chains in Latin America, Upgrading to Compete Global Value Chains, Clusters, and SMEs in Latin America, Inter-American Development Bank, David Rockefeller Center for Latin American Studies, Harvard University.
18. Rodrik, D. (2013): *Unconditional convergence in manufacturing*. The Quarterly Journal of Economics, (128): 165–204.
19. Strange, R. (2020): *The 2020 Covid-19 pandemic and global value chains*, Journal of Industrial and Business Economics (2020) 47:455–465.
20. Vivek, S. D.; Richey, R.; Dalela, V. (2009): *A longitudinal examination of partnership governance in offshoring: A moving target*. Journal of World Business, 44(1): 16–30.

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MARKET REQUIREMENTS AND INNOVATIVE PERSPECTIVES IN THE FURNITURE INDUSTRY

Erika Loučanová, Miriam Olšiaková, Martina Nosáľová

Abstract: The paper focuses on selected attributes of customers' requirements for furniture and innovative perspectives in the furniture industry in Slovakia. The primary method of identifying customer requirements was the Kano model method. In terms of research, Slovak customers most often accepted furniture criteria are revealed using the Kano model. The findings show differences in consumers' requirements for particular features and innovative attributes of the furniture industry. The popularity of the individual investigated attributes is related to their perception either as traditional or radical innovations in this sector. From the point of view of the perception of innovations, we can classify customers in Slovakia as conservative, as they prefer the requirements and attributes of furniture associated with their traditional design. These results identify market requirements and innovative perspectives in the furniture industry in Slovakia, with the potential of use for creating furniture sales strategies.
Key words: customers' requirements, furniture sector, Kano model

1. INTRODUCTION

The aim of innovation is to improve the company's performance by achieving the competitive advantage or maintaining the achieved competitiveness by shifting the demand curve of the company's products. The furniture industry is characterised according to the OECD as a low-tech sector (2002, In Karagouni et al., 2010; Pirc and Vlosky, 2010), where innovation is rather based on the adoption than the invention and it is typified by incremental innovation (Anon, 2005). The tendency to perform incremental innovation rather than radical ones may be related to the subcontracting characteristic in the relationship between actors in the wood-furniture industry (Kusumawardhani and McCarthy, 2013). Under such circumstances, innovation activities are rather focused on production efficiency, product difference and marketing. Additionally, financing may be a factor that influences innovation in small and medium-sized furniture industry businesses (Anon, 2005). This is caused on by the lack of resources available to businesses for the development of radical ideas, which they are unable to secure anyway due to the ease of counterfeiting. In general, markets do not appreciate or value radical innovative efforts from the firms, therefore they are not willing to pay extra cost to make them profitable either (Otero-Neira et al., 2009). Due to the high expense of implementing new technology and the shortage of staff with the necessary skills, small and medium-sized businesses are less inclined to adopt it (Yan Yi et al., 2021). Another important characteristic of the furniture industry is its lack of globalisation in the means of that there are differences in the competitive structures among the countries, affecting innovation performance (Otero-Neira et al., 2009).

In the furniture industry, the technological and market turbulences are not supposed to be the critical variables that explaining variations in the innovative performance of furniture companies. This is explained by the presumption that these mentioned turbulences are rather low across the sector, and there are not many notable disparities in consumers' requirements across the various countries. In particular, the technological field presents fixed standards, and consumers have quite similar demands, which are not subject to particularly radical changes. In fact, we can expect that in the furniture industry, innovations are not very radical, and all companies undertake incremental innovations. This tendency of companies to perform incremental innovation rather than radical innovation is consistent with other studies (Kusumawardhani and McCarthy, 2013; Otero-Neira et al., 2009). This could imply that the furniture sector shows a tendency to innovate based only on its market orientation, and not on its internal tendency to develop technology, probably because it is a traditional, “low-tech” sector (O’Regan and Ghobidian, 2005).

Customer preferences in connection with furniture were obviously analysed around the world, for example in studies of Pirc Barčić et al. (2021), Jost et al. (2020), Andac Guzel (2020) as well as in Slovakia in studies of Kaputa et al. (2018), Loučanová et al. (2022), Olšiaková et al. (2016), Paluš et al. (2012). The results of Jost et al. (2020) research showed that customers’ preferences for furniture materials have changed in the last decade. Similarly, the factors that influence their purchase decisions when buying interior and exterior furniture have changed as well. Survey (Balicka and Niedbała, 2022) indicates that the most common factors influencing the decision during purchase that characterize the furniture are those related to design and aesthetics Price-related factors are fairly important to customers and quality-related factors are the least important.

The issue of innovation in the furniture industry was dealt with, for example, by the authors Ototo and Vlosky (2023), Ling and Laksitamas (2022), Kumburu and Kessy (2021), Kusumawardhani and McCarthy (2013), Karagouni et al. (2010), Pirc and Vlosky (2010), Otero-Neira et al. (2009), as well as Loučanová et al. (2020) in Slovakia. As noted by Padilha and Cziulik (2005), it has been observed that to develop new products most furniture companies are employing inadequate strategies and therefore, some products do not fulfil the customer expectations. Knowing the attitudes and requirements of customers is essential and this applies to the furniture industry. Therefore, the focus of this study is to identify consumers' requirements for particular features and innovative attributes of the furniture industry.

2. METHODOLOGY

The Kano model was the main technique applied to assess Slovak consumers' perceptions of innovation regarding the furniture. To determine the factors that differentiate the product and provide it a distinct market position, it considers theories of contradiction. The analysis is mostly concerned with those attributes of furniture that consumers consider to be attractive, mandatory, and required, what in the conditions of the Kano model can be specified as: attractive (A), mandatory (M), reverse (R), one-dimensional (O), questionable (Q) or indifferent (I). From the perspective of the customer, the mandatory requirements are significant since, in the event of non-compliance, they result in strong dissatisfaction. However, if they are satisfied, their impact on customer satisfaction is minimal. It's a fundamental requirement for a product that customers demand automatically. One-dimensional requirements are those that have a linear relationship between customer satisfaction and their fulfilment. The consumer is more satisfied when more conditions are met. Requirements that boost customer pleasure exponentially are examples of attractive values. Considering the information provided above, these requirements have the most significant impact on consumer satisfaction. In addition to the requirements listed, Kano model also identify reverse, questionable, and indifferent requirements with reverse or none influence on the consumers. Individual criteria naturally overlap and impact one another, making it impossible to strictly separate them. (Loučanová, 2021, Loučanová and Olšiaková, 2020).

The analysis of parameters focused on the examined problem was followed by the methodical procedure to assess requirements for traditional and innovative features of furniture by Slovak consumers, such as (Besch, 2005, Kotler et al., 2015, Loučanová et al., 2021, Farkašová and Baďura, 2021):

- Price – representing a monetary expression of the good or service value.
- Ergonomics – representing furniture that has a positive impact on the customer's comfort when using furniture and its surroundings, including other users of the space.
- Quality – representing the sum of the characteristics, the condition, the nature of the object meeting certain standards.
- Design – representing natural or intentional surface patterns of utility objects.
- Material – representing the substance or summary of individual products serving for a particular further use or processing.
- Services - are the intangible result of a particular economic activity aimed at meeting human needs.
- Innovation furniture (where innovation means any quantitative or quality purposeful change) with a focus on:
  - Remote control – understood as an electronic device, as additional furnishings to furniture used for its remote control.
  - Intelligent solution – a smart module that can replace multiple pieces of furniture.
  - Magnetic closure – representing components for furniture which serve to tightly close the opening parts of furniture with the possible use of a magnetic key.
  - Backlight – representing several types of light source within the furniture regarding the purpose but also the function that the light will perform.
  - Levitation – under this type of furniture we mean the floating furniture, where it is not only a real levitation of furniture, but it is an optical delusion, i.e. the supporting point of the furniture is made of transparent material.
  - Services – services for furniture can include one or several of the following elements: Design for durability (to reduce the environmental impacts of furniture consumption); Maintenance and repair services; Reuse of furniture parts; Remanufacturing of used furniture; Servitization - leasing or renting to furniture.

Regarding exact parameter determination, a questionnaire including the requirements of the KANO model was created. It involved the generation and formulation of two questions for each examined parameter. In the first step, the question was formulated to detect the consumers´ responses on whether their requests were met. On the contrary, in the second step, the question was formulated in a way that the consumers' requests were not met. Consumers had the opportunity to express agreement or disagreement with the question or statement on the Likert scale (1 – like, 5 – dislike). Then measures for the questionnaire implementation were determined. The sample consisted of 408 respondents, which meets the minimum sample of 400 respondents, with the required confidence interval of 95 %, accessible error range of 5 %. The KANO model was used to evaluate the collected data, classifying individual responses into predetermined categories using a cross-rule. The features of furniture are classified as mandatory, attractive, one-dimensional, indifferent, and reverse. Regarding the sample's descriptive statistics, women completed the survey at a higher rate than males (70.34% of total responses). 36.27% of participants were from 18 to 30 years old, 30.39% of the participants were from 31 to 50 years old, 15.20% of the participants were from 51 to 60 years old and 18.14% of the participants were over 61 years old.

Following the use of a questionnaire to conduct the survey, a database containing the collected data was created. Within this database, the requirements for traditional and innovative features of furniture by Slovak were defined, and a numerical expression of the degree to which consumers agreed or disagreed with the given question regarding the defined parameter was then assigned. For each parameter, the individual answers to the positively and negatively asked questions (statements) were evaluated separately using the cross rule of the KANO model (Table 2). By such a determination, individual properties can be specified as follows: attractive (A), mandatory (M), reverse (R), one-dimensional (O), questionable (Q) or indifferent (I).

Table 1. KANO model for evaluation of consumer requirements

		Answer to the Dysfunctional Question				
		Like	Acceptable	No Feeling	Mandatory	Do not like
Answer to the Functional Question	Like	Q	A	A	A	O
	Acceptable	R	I	I	I	M
	No Feeling	R	I	I	I	M
	Mandatory	R	I	I	I	M
	Do not like	R	R	R	R	Q

Source: Grapentine, 2015, Loučanová, 2021, Loučanová and Olšiaková, 2020

The consumer requirements that were identified were divided into categories and rearranged in relation to the percentage proportions of the respondents' sample. The most represented group of requirements characterize the resulting perception of the examined parameter or value. Based on the above-described methodical procedure, the monitored quantities (requirements) of customers were identified when purchasing the furniture. The answers to these questions are a summary of the requirements for furniture purchase and furniture innovations on the market.

3. RESULTS AND DISCUSSION

Within the framework of the analysis, we focused on selected attributes of customers' requirements for furniture and innovative perspectives in the furniture industry in Slovakia. Based on the research carried out according to the established methodology, we reached the following results, see figure 1.

When buying furniture, customers consider design (66.67 %) and quality (38.48 %) to be the mandatory requirements that furniture shall meet. Similar results have been published in previous studies (Kaputa et al.2018) finding that two of the most relevant purchase decision factors are quality and design. According to study of Pirc Barčić et al. (2021) the high proportions of positive preferences for functionality, quality, and design showed that these purchase factors are very important for consumers in the purchase decision process. Ergonomics (41.18 %) and services (32.6 %) are identified as attractive requirements for respondents. According to our findings, these requirements, such as ergonomics, quality, design and service, are considered by respondents to be the basic criteria for their purchasing decisions. Other requirements, such as price, material and furniture innovation, do not affect respondents' purchasing decisions. It means they have no significant effect on their satisfaction or dissatisfaction.

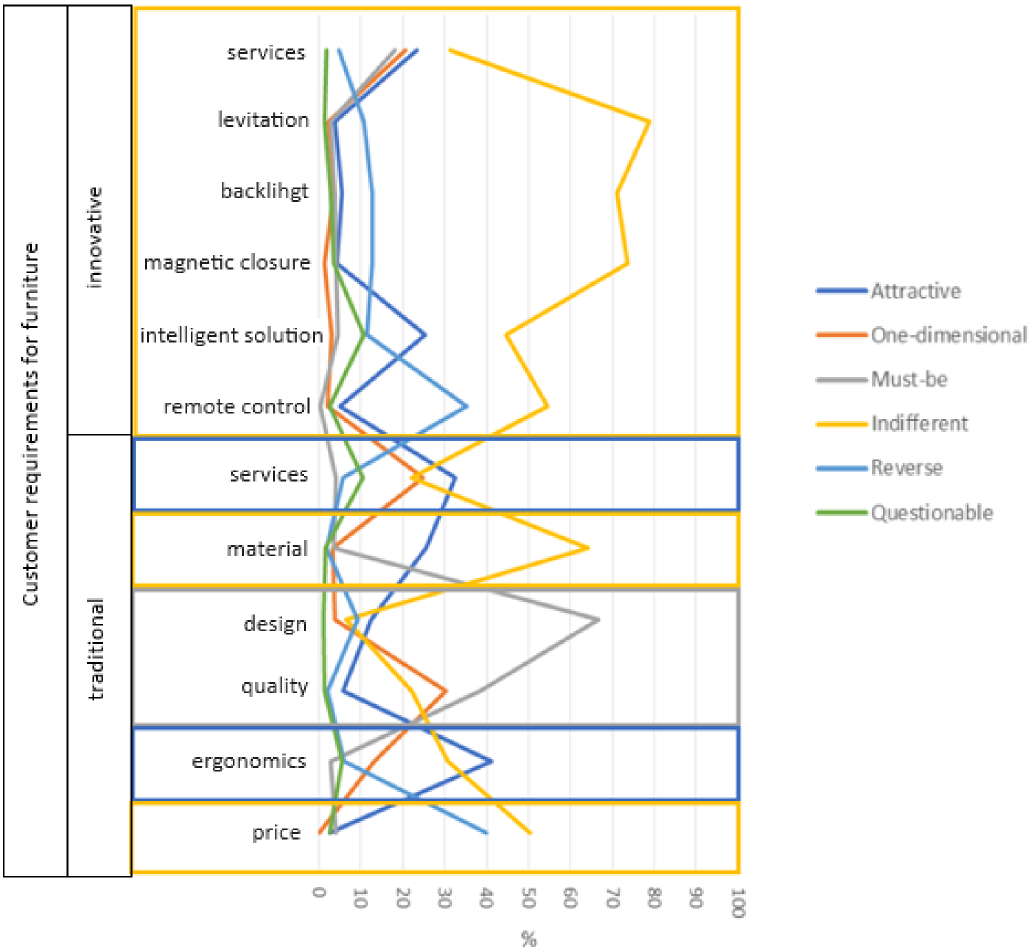

Figure 1. Customer´s requirements for traditional and innovative features of furniture

The price of furniture does not affect purchasing decisions (50.49 %), respondent identified the price as indifferent requirement. However, 39.95 % of respondents perceive the price of furniture as reverse requirement - they are influenced by the price in the opposite way in sense if their requirements are not met, it is perceived in a contradictory way. This is consistent with the finding of Pirc Barčić et al. (2021), that buying furniture at a lower price or discounted products are not that important to the costumers. According to our results, the demand for material is perceived similarly – as indifferent requirement. The parameter of the material showed minimal changes in consumer behaviour. It is also worth mentioning that for

25.5 % of respondents the used material is perceived as an attractive requirement. It means that if the material requirements are met, customers are very satisfied, even if they do not primarily expect it. This may be caused by wood material itself, which is preferred to substitute materials for processing furniture (Paluš et al., 2012). This is consistent with Andac Guzel´s paper (2020) indicated that the wood is natural and make people to enjoy it, and furniture is a most frequent way of utilizing wood for consumers at home. As far as the material requirement is concerned, environmental issues can also be influential, according to findings of Ling and Laksitamas (2022), that there is respondents' agreement who believe using environmentally friendly materials can bring customer convenience and environmentally friendly materials have a significant impact on customer perceived value.

With respect to the furniture innovations, we also generally observed an indifferent influence on respondents' purchasing decisions and subsequently most respondents perceive them in a reverse way. However, in the case of intelligent furniture solution, 25.5 % of respondents perceive this innovation as an attractive one, which means that they do not expect it, but if this requirement is met, the customer is satisfied. This is similar with the service innovations, which are attractive for 23.28 % of respondents. Therefore, it is necessary for furniture retailers to focus mainly on meeting the elementary requirements, such as identified quality and design, and subsequently take advantage of the attractiveness of ergonomics and customer service. Intelligent furniture solutions and provided innovative services appear to be adapting furniture innovations on the Slovak market, which represents an equally great potential for furniture retailers in terms of attracting customers. This finding is consistent with Papadopoulos et al (2018) as ecological and intelligent furniture appears to gain popularity since both smart multi-functionality and eco-sensitivity seem to grow, consumers are regarding the attractiveness of green smart furniture (GSF) products.

Results also confirm the focus of consumers on quality, as stated by e.g. Rametsteiner et al. (2007), who presents similar attitudes of consumers towards the listed categories of wood products and describes the differences in preferred properties such as design and quality. It also points out the wood competitiveness as a material regarding its features. Wood is a resource that Slovakia disposes, and it also represents renewable wealth that follows the tradition of wood processing industry in the country. In cooperation with forestry, it creates a chain of traditional industries in Slovakia (Olšiaková et al., 2016).

4. CONCLUSION

To meet the demands and desires of the customers, it is crucial to understand certain characteristics of the purchasing behavior of Slovak furniture customers, which is why we examined how the furniture and its innovation requirements in the market are seen. According to the findings, the consumers mainly focus on quality and design, which represents their greatest satisfaction but also the greatest dissatisfaction in case when their requirements have not been met. The parameters of ergonomics and services present attractive requirements resulting in consumers' satisfaction. Our results indicate that it is critical to focus on the furniture's quality and design, followed by its ergonomics and customer-friendly services. At the moment, innovation by itself does not significantly affect consumers' purchase decisions. However, some customers find advancements pertaining to intelligent furniture solutions and novel services to be quite appealing. Furniture retailers should therefore pay close attention to those aspects when creating a marketing strategy.

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REFERENCES

1. Andac Guzel, T. (2020). *Consumer attitudes toward preference and use of wood, woodenware, and furniture: A sample from Kayseri.* BioResources 15 (1): pp. 28-37.
2. Anon. (2005): *Oslo Manual Guidelines for Collecting and Interpreting Innovation*. OECD Publication, Paris.
3. Balicka, A.; Niedbała, M. (2022): *Social factors affecting consumer decisions during purchasing furniture in Poland*, Annals of Warsaw University of Life Sciences SGGW Forestry and Wood Technology, vol. 118, 22-34.
4. Besch, K. (2005): *Product-service systems for office furniture: barriers and opportunities on the European market*. Journal of Cleaner Production, 13, 1083-1094.
5. Erstad, M. (1998): *Mystery shopping programmes and human resource management*. International Journal of Contemporary Hospitality Management, 10 (1): pp. 34-38.
6. Farkašová, E.; Baďura, R. (2021): *Understandings of design in circumstances of humanity*. Acta Facultatis Xylologiae Zvolen, 63 (1): pp. 143-150.
7. Jost, M.; Oblak, L., Perić, I., Pirc Barcic, A., Nosáľová, M., Kaputa, V. (2020): *Changes in Customer Preferences for Furniture in Slovenia*. Drvna Industrija 71: pp. 149-156.
8. Kaputa, V.; Pirc Barcic, A.; Maťová, H.; Motik, D. (2018): *Consumer Preferences for Wooden Furniture in Croatia and Slovakia*. Bioresources 13 (3): pp. 6280–6299.
9. Karagouni, R.; Papadopoulos, I., Trigkas, M. (2010): *The innovativeness of Thessalian wood and furniture SMEs: towards an understanding of internal and external drivers*. pp. 31-48.
10. Kotler, P.; Burton, S., Deans, K., Brown, L., Armstrong, G. (2015): Marketing. Pearson Higher Education, AU.
11. Kumburu, N. P.; Kessy, J. F. (2021): *Consumers' Preference on Imported and Locally Made Furniture in Dar es Salaam and Arusha, Tanzania*. Global Business Review 22(1): pp. 23-35.
12. Kusumawardhani, A.; Mccarthy, G. (2013): Innovation in Small and Medium-Sized Wood-Furniture Firms in Central Java, Indonesia. In: Proceedings of the International Conference on Managing the Asian Century. Springer, Singapore.
13. Ling, C.; Laksitamas, P. (2022): *The customer perceived values on green furniture innovation based on 4C theory and practice in PRC*. Journal of Management Information and Decision Sciences 25(S7): pp. 1-10.
14. Loučanová, E.; Olšiaková, M. (2020): *Identification of customers'drivers for the wood building as an ecological innovation in building construction in Slovakia*. Acta Facultatis Xylologiae Zvolen 62: pp: 177-188.
15. Loučanová, E.; Olšiaková, M., Paluš, H. (2022): *Perception of supplied furniture and its innovation by Slovak customers*. Acta Facultatis Xylologiae Zvolen, 64(1): pp.113-121
16. Loučanová, E.; Šupín, M., Čorejová, T., Repková-Štofková, K., Šupínová, M., Štofková, Z., Olšiaková, M. (2021): *Sustainability and branding: An integrated perspective of eco-innovation and brand*. Sustainability 13 (2): 732.

17. O'regan, N.; Ghobidian, A. (2005): *Strategic planning: a comparison of high and low technology manufacturing small firms*. Technovation 25: pp. 1107-1117.
18. Olšiaková, M.; Loučanová, E., Paluš, H. (2016): *Monitoring changes in consumer requirements for wood products in terms of consumer behavior*. Acta Facultatis Xylologiae Zvolen 58(1): pp. 137-147.
19. Otero-Neira, C.; Tapio Lindman, M., Fernández, M. J. (2009): *Innovation and performance in SME furniture industries*. Marketing Intelligence & Planning 27: pp. 216–232.
20. Ototo, G.O.; Vlosky, R.P. (2023): *Deconstructing innovation in the wood furniture industry in Kenya.* Journal of Forest Business Research 2(2): pp. 1-32.
21. Padilha, J.; Cziulik, C. (2005): *Strategic innovation management in the furniture industry.* Product Management and Development 3 (1): pp. 73-77.
22. Paluš, H.; Maťová H., Kaputa, V. (2012): *Consumer preferences for joinery products and furniture in Slovakia and Poland*. Acta Facultatis Xylologiae 54 (2): pp. 123-132.
23. Papadopoulos, I.; Karagouni, R., Trigkas, M. (2018): *Consumers' perceptions on green and smart furniture innovation*. International Journal of Electronic Marketing and Retailing. 9 (1): pp. 22-36.
24. Pirc Barcic, A.; Kitek Kuzman, M., Vergot, T., Grošelj, P. (2021): *Monitoring Consumer Purchasing Behavior for Wood Furniture before and during the COVID-19 Pandemic*. Forests 12 (7): 873.
25. Pirc, A.; Vlosky, R. (2010): *Comparison of Innovation in the Furniture Manufacturing Industries of Croatia and the United States*. In Proceedings of the International Conference WoodEMA–Present Conditions, Opportunities and New Challenges, Vyhne, Slovakia, 2010; 149–156.
26. Shahin, A.; Pourhamidi, M.; Antony, J.; Hyun Park, S. (2019): Typology of Kano models: *A critical review of literature and proposition of a revised model*. International Journal of Quality & Reliability Management 30 (3): pp. 341-358.
27. Yan Yi, L.; Ab Latib, H., Ratnasingam, J., Mariapan, M., Choon Liat, L., Othman, K., Amir, M. A., Jegatheswaran, N. (2021): *Readiness for and adoption of Industry 4.0 among small and medium sized enterprises in the Malaysian furniture industry*. BioResources 16 (4): pp. 8289-8308.
28. ***:Grapentine, T. (2015): *Why the Kano model wears no clothes*. Quirks Marketing Research Media, 34. URL: http://www.quirks.com/articles/2015/20150407.aspx
29. ***Rametsteiner, E.; Oberwimmer, R., Gschwandtl, I. (2007): *Europeans and wood: What do Europeans think about wood and its uses? A review of consumer and business surveys in Europe.* Warsaw: Ministerial Conference on the Protection of Forests in Europe, Liaison Unit Warsaw. URL: https://www.researchgate.net/publication/282573684_EUROPEANS_AND_WOOD_What_Do_Europeans_Think_About_Wood_and_its_Uses_A_Review_of_Consumer_and_Business_Surveys_in_Europe.

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FUTURE DEVELOPMENT OF WOOD SUPPLIES POTENTIAL FOR THE SLOVAK FOREST-BASED INDUSTRY – INSIGHTS FROM SPRUCE GROWING STOCK FORECASTS

Michal Dzian, Martin Moravčík, Hubert Paluš, Ján Parobek

Abstract: Forest-based sector in Slovakia is highly dependent on the availability of coniferous wood resources. Spruce as the most present coniferous tree species in the country plays a key role for the wood supplies to sawmilling and panel industries and its processing contributes significantly to the economic development of the country. Any fluctuations in supplies can have a major impact on the market and production perspectives in the forestry-based sector. The aim of the study is to assess the sustainable management and long-term viability of Norway spruce resources and to develop a forecast of spruce growth and harvesting potential up to 2050 in Slovakia. The analysis of historical data proved that the spruce cover has decreased by 13.2% since 2010 and its growing stock by 16.4% over the same period. The forecast of spruce growing stock and felling until 2050 was estimated separately for two scenarios based on the development of (i) growing stock and actual cutting percentages in the period 2012–2020 and (ii) cutting percentages according to the planned felling. The results of the study show that there is projected a significant decrease in the growing stock in spruce stands and thus expected reduction in availability of wood supplies for the forest-based sector.
Keywords: Norway spruce, forecast, spruce stands, growth model, harvesting model

1. INTRODUCTION

Norway spruce (Picea abies [L.] H. Karst.) is an economically important European tree species, representing a quarter of Europe's growing stock, and it is also one of the most present tree species in Slovakia (Potterf et al. 2023; National Forest Centre 2023b). Slovakia is a country rich in forest resources. Over the years, its forest area has increased steadily. In 2022, natural forests covered 2.37 million hectares, about 42% of the country's land area (National Forest Centre 2023b). In Slovakia Norway spruce grows in mixed forests and in monocultures up to the upper limit of the forest at altitudes of 1,500–1,550 m above sea level (Moravčík et al. 2021). In 2022, European beech (34.8%), spruce (21.5%), and oak (10.4%) were the most abundant species. The representation of conifers (35.5%) has been decreasing steadily due to harmful agents influencing forests (especially wind and bark beetle) (National Forest Centre 2023a). However, due to the vulnerability of Norway spruce resulting from its shallow root system, the proportion of Norway spruce is expected to decrease to less than half of its present share (National Forest Centre 2023b; 2023a). Recent studies have shown an increase in disturbance intensity in managed forests, which could potentially affect spruce supply (Potterf et al. 2023). In the recent years, drought, windthrow and bark beetle outbreaks have led to an unprecedented increase in spruce mortality (Härkönen et al. 2019).

Spruce forest stands produce a significant volume of high quality logs that belong to the most important forestry products in the Slovak Republic, accounting for 61.3% of the softwood supplies and 31% of the total wood supplies, respectively. An analysis of the material flows showed that more than 84% of the total resources are used for industrial purposes and almost

16% are used for the production of energy (Parobek et al. 2014). This is an indication of the strong dependence of the forest-based industry on the supply of wood raw material, including spruce. The forest-based industry plays a pivotal role in Slovakia's economy, with a significant increase in foreign investments documented in the recent years (Slovak Investment and Trade Development Agency 2011). However, the industry's share on the Slovak economy remains relatively low with the most important role of the pulp and paper industry. The industry faces challenges due to climate change and the need for sustainable and nature-close forest management practices. Despite these challenges, the sector continues to grow and make a significant contribution to the economy of the country.

The aim of this paper is to evaluate the sustainable management and the long-term viability of Norway spruce in Slovakia. It is essential to understand the future growth and harvesting potential of this species, and the need for sustainable forest management practices. Therefore we aim to develop a forecast model for the growth and harvesting potential of Norway spruce up to 2050.

2. MATERIAL AND METHODS

Using the data from the Summary Information on the State of Forest (SISF) for the years 2010–2020, the analyses of the development of the area and the growing stock of spruce in the forests of the Slovak Republic were carried out. Data on total spruce felling, classified by age classes and divided into planned (tending felling and regeneration felling) and incidental felling were obtained from the forest management records for the years 2012-2020. A modified methodological procedure according to Greguš (1989) was applied to develop the forecast of spruce growing stock and felling until 2050. Following this approach, the timber allowable cut is proportional to the growing stock in forests and cutting percentages. Thus, the values of these two variables have the greatest influence on the derived allowable cut of timber. Considering the felling volume and the level of accidental felling in spruce stands, two basic scenarios based on the following two assumptions were determined.

In the case of Scenario A, we assumed that the current extent of spruce stand damages by the action of harmful agents will continue at the same trend as in the previous decade (2010–2020) as a result of the impacts of climate change and the limitations of standard forest management. The following formula was used to determine the forecast:

$$DFP_{ia} = \frac{TYF_{ia}}{GS_{sw}} * 100 \qquad [1]$$

where:
i – index indicating the age class
DFP_{ia} – decennial felling percentage according to the actual volume of spruce felling
TYF_{ia} – actual volume of ten-years spruce felling until 2020
GS_{sw} – growing stock of spruce in m^3

In the case of Scenario B, we assumed that the felling of spruce will be equal to the volume of planned felling and corresponding felling percentages (according to SISF). To determine the forecast in scenario B, the following formula was used:

$$DFP_{ip} = \frac{TYF_{ip}}{GS_{sw}} * 100 \qquad [2]$$

where:

DFP_{ip} – decennial felling percentage according to the planned volume of spruce felling
TYF_{ip} – planned volume of ten-years spruce felling until 2020

3. RESULTS AND DISCUSSION

In the period 2010 to 2020, there were significant changes in the share of spruce area and the growing stock of the spruce. In 2020 compared to 2010, the spruce area decreased from 445 thousand hectares to 385 thousand hectares, a decrease of 13.2% (Fig.1).

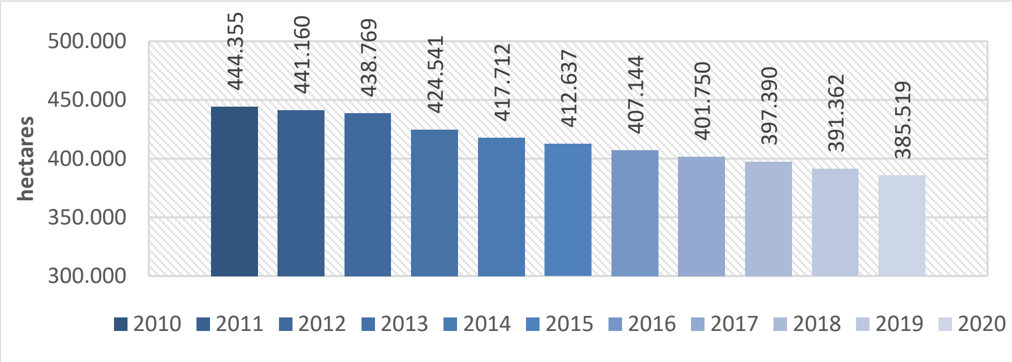

Figure 10 Development of spruce area

At the same time, the growing stock has decreased over the same period. It decreased by 16.4% from an initial volume of about 137 million cubic metres to the current volume of 115 million cubic metres (Fig. 2). This reduction in the growing stock could be due to the decrease in spruce area, but it could also be influenced by other factors such as changes in forest management practices or natural disturbances.

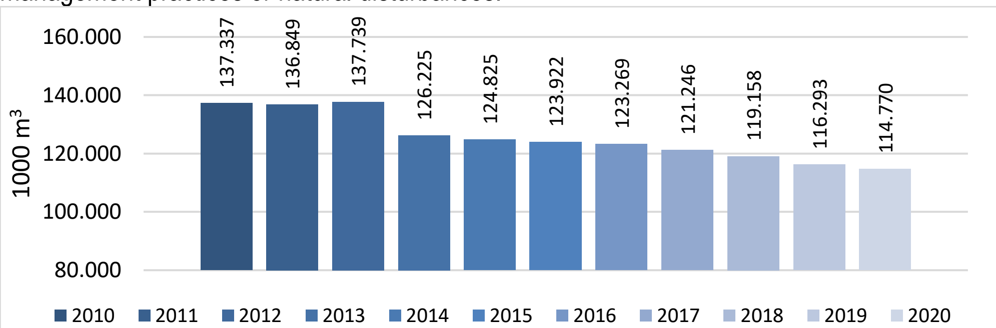

Figure 11 Development of spruce growing stock

The distribution of spruce across different age classes shows an uneven pattern (Fig. 3). The older stands, specifically those aged between 61 and 110 years (age classes 7–11), have been experiencing an annual decrease in their spruce share. This could be due to natural aging processes or external factors such as disease, pests, or environmental changes. In contrast, the oldest stands, those above 111 years (age classes 12–15+), have maintained a steady spruce share. Interestingly, there has been a noticeable increase in the spruce share particularly in the younger stands (age classes 1, 2, 5, and 6). This could be a result of successful regeneration efforts or favorable growth conditions for younger trees. These observations underline the importance of continuous monitoring and adaptive management strategies to ensure the health and sustainability of spruce stands across all age classes. Further studies could help in understanding the factors influencing these trends and in developing effective forest management practices.

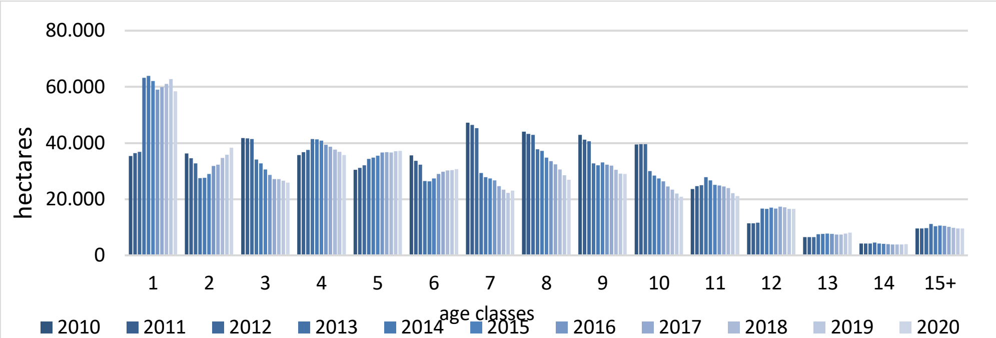

Figure 12 Development of spruce area in age classes

The same trends in the age classes can also be observed in the development of growing stock of spruce. Above mentioned trends of the area representation and growing stock of spruce with a significant decrease in the middle and older ages, indicate a reduction in the felling possibilities of spruce wood in the coming decades.

The future forecast of spruce felling development was derived considering two scenarios as mentioned above. The scenario A assumes that due to climate change and restrictions to normal forest management, mainly due to nature protection, the damage to spruce forest stands by the action of harmful agents will continue at approximately the same extent as in the previous decade. To derive the related forecast, average cutting percentages adjusted by polynomial function corresponded to actual volume of felling (performed planned and incidental felling) in the years 2012–2020. In this case, a significant reduction in spruce growing stock is expected from the current 114.8 mil. m^3 to 86.9 mil. m^3 (by 24%) in 2030 and to 74.3 mil. m^3 (by 36%) in 2040. In the case of scenario B, under which it is assumed that the felling volume would correspond to the volume of planned felling and the related felling percentage, the decline in wood stock would be more moderate, by 10.6% (to 102,6 mil. m^3) in 2030, or by 15.5% (to 96.9 mil. m^3) in 2040, respectively (Fig. 4).

Considering the scenario A, the decennial spruce felling carried out in period 2021–2030 in the volume of 42.6 mil m^3 would drop later on in the years 2031–2040 to 32.0 mil. m^3 and to 25.7 mil. m^3 in the years 2041–2050. Under the scenario B, the volume of spruce felling in the next three decades would be lower reaching 29.3 mil. m^3, 26.0 million m^3 and 23.8 mil. m^3, respectively (Fig. 5).

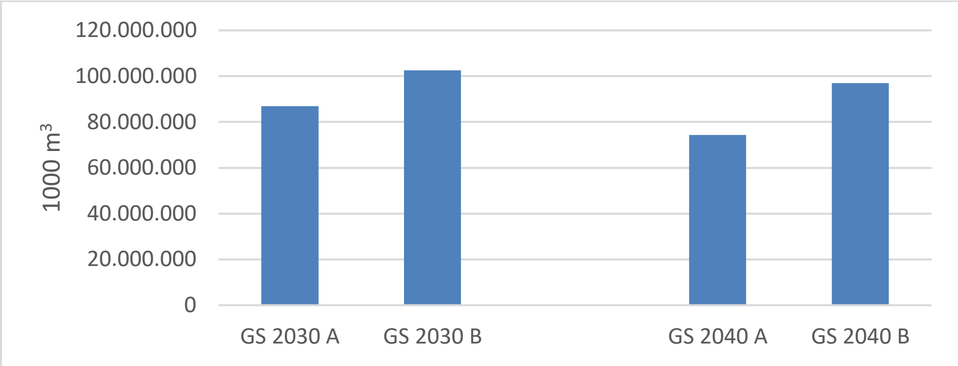

Figure 13 Comparison of forecasted spruce growing stock in 2030 and 2040 under scenario A (GS 2030 A and GS 2040 A) and B (GS 2030 B and GS 2040 B).

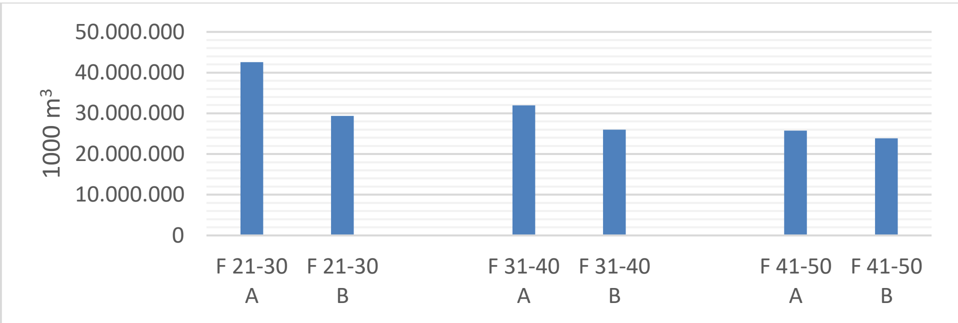

Figure 14 Comparison of forecasted spruce felling (F) in 2030, 2040 and 2050 under scenario A and B.

From the point of view of maintaining representation of spruce in forest stands, scenario B seems to be more advantageous compared to scenario A. However, as a result of the ongoing persistence of the action of harmful agents due to climate change and due to current stand and management conditions, scenario B is not likely to be fulfilled.

4. CONCLUSION

This study focusing on develop a forecast model for the growth and harvesting potential of Norway spruce up to 2050. The Norway spruce, has exercised a decrease in cover by 13.2% and the reduction in growing stock by 16.4% since 2010. The study highlights the urgent need for sustainable management strategies to ensure the long-term viability of the Norway spruce, a critical resource for Slovakia’s forest-based sector. The industry and the country's economy face major challenges from the projected decline in spruce stocks and the expected reduction in wood supply.

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REFERENCES

1. *Greguš, C., 1989: Metodický postup odvodenia výhľadových a prognózovaných ťažbových etátov. Lesnícky časopis – Forestry Journal, 35:17–31. (In Slovak).*
2. Härkönen, S., Neumann, M., Mues, V., Berninger, F., Bronisz, K., Cardellini, G., Chirici, G., Hasenauer, H., Koehl, M., Lang, M., Merganicova, K., Mohren, F., Moiseyev, A., Moreno, A., Mura, M., Muys, B., Olschofsky, K., Del Perugia, B., Rørstad, P. K., … Mäkelä, A. (2019). A climate-sensitive forest model for assessing impacts of forest management in Europe. *Environmental Modelling and Software*, *115*(August 2018), 128–143. https://doi.org/10.1016/j.envsoft.2019.02.009
3. Moravčík, M., Kovalčík, M., Kulla, L., 2021: Produkcia dreva a jeho spracovanie v drevospracujúcom priemysle. Kapitola (Lesnícko-drevárska vertikála) do Koncepcie spoločných postupov pri budovaní moderného pôdohospodárstva v horizonte 2035. Úloha odbornej pomoci pre MPRV SR. NLC 2021. 12 p. (unpublished) (In Slovak).
4. National Forest Centre. (2023a). *Správa o lesnom hospodárstve v Slovenskej Republike za rok 2022*.
5. National Forest Centre. (2023b). *Súhrnné informácie o lesoch Sloveska*. https://www.forestportal.sk/odborna-sekcia-i/informacie-o-lesoch/suhrnne-informacie/
6. Parobek, J., Paluš, H., Kaputa, V., & Šupín, M. (2014). Analysis of wood flows in Slovakia. *BioResources*.
7. Potterf, M., Svitok, M., Mezei, P., Jarčuška, B., Jakuš, R., Blaženec, M., & Hlásny, T. (2023). Contrasting Norway spruce disturbance dynamics in managed forests and strict forest reserves in Slovakia. *Forestry*, *96*(3), 387–398. https://doi.org/10.1093/forestry/cpac045
8. Slovak Investment and Trade Development Agency. (2011). *FORESTS AND A WOOD - PROCESSING INDUSTRY.* https://www.sario.sk/sites/default/files/content/files/woodprocessing_en.pdf

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DIGITAL MARKETING STRATEGIES TO PROMOTE FURNITURE MANUFACTURING MSMEs

Gloria Ilieva

Abstract: Small and medium-sized enterprises and micro firms dominate the furniture industry in the EU. While large corporations can have marketing departments focusing on promoting the business, MSMEs don't have access to the budgets and human resources to build a strong marketing presence. Strategies that could help MSMEs in the furniture manufacturing business grow and build a strong digital presence through content creation, ads, and partnerships while responding swiftly to market demands will be presented. They are adopted from other industries to fit the peculiarities of the furniture manufacturing sector and the restrictions that MSMEs are facing
Keywords: MSME, digital marketing, strategy

1. USE OF DIGITAL MARKETING BY MSMEs IN THE FURNITURE MANUFACTURING SECTOR

The power of marketing in today's economic environment is undeniable. Marketing builds the demand for products and services, supporting the growth of the firm. Even though companies understand the importance of marketing for their business few are performing well in their marketing efforts.

Marketing plays a pivotal role in promoting innovation and enhancing the value offered to consumers. It provides insights into consumer needs and preferences, guiding the development of new products and services that fulfill unmet demands. This process of innovation contributes to economic growth by introducing new market opportunities and improving productivity.

Marketing enables businesses to differentiate themselves from competitors, build brand equity, and establish loyal customer bases. By effectively communicating value propositions and building relationships with consumers, companies can secure a competitive edge in saturated markets.

Modern marketing also aligns with the principles of sustainability and social responsibility. Through green marketing initiatives and ethical business practices, companies contribute to environmental conservation and social welfare. This approach not only fosters long-term economic development but also enhances corporate reputation and stakeholder trust.

1.1. Survey on marketing efforts in MSMEs in Sofia, Bulgaria

The author surveyed 50 respondents at the entrance of one of the bigger stores for components used in manufacturing furniture to gain an understanding of their marketing efforts. The sample size consists of a majority of micro companies with less than 10 employees, 22% work for small enterprises between 10-25 employees, and 0 of the interviewed are from companies with 25-50 employees.

Table 1. Survey questions and percentage of responses

What's the size of the company you work for?	
1-10 people	78%
10-25 people	22%
25-50 people	0%
Does your company have a website?	
Yes	26%
No	74%
Does your company have a Facebook page?	
Yes	56%
No	44%
Does your company have an Instagram account?	
Yes	12%
No	88%
Does your company have a TikTok account?	
Yes	6%
No	94%
If you've answered any of the questions above with yes, can you advise how frequently you post?	
Several times a week	4%
Once per week	8%
Once per month	20%
Occasionally (less than 1 per month)	64%
I haven't used the page after creating it	4%

Only 26% of the companies represented in the survey have a website, indicating that a significant proportion of small businesses may not be fully leveraging the potential of online platforms.

Over half of the respondents (56%) indicated that their company has a Facebook page, which could reflect the platform's ease of use and prevalence among businesses. Only 12% of companies have an Instagram account, and even fewer (6%) have a TikTok account, highlighting a potential underutilization of these platforms for business, particularly given their growing user bases and engagement rates.

For the companies that have some form of digital presence (as indicated by a 'yes' in the previous questions), most of them (64%) post content only occasionally (less than once a month). A smaller percentage post once per month (20%) or once per week (8%). Very few companies post several times a week (4%), and an equal percentage (4%) have not used their page after creating it.

These findings suggest that there is a significant opportunity for growth in the digital space for MSMEs working in the furniture manufacturing sector. The low percentage of companies with a website and the complete absence of Google Ads usage point toward a gap in adopting online marketing strategies. While a majority have a Facebook presence, the low engagement rates, especially on more visually-oriented platforms like Instagram and TikTok, could indicate a lack of resources, knowledge, or confidence in how to effectively utilize these platforms for business growth.

The data points to the need for greater digital marketing education and resources targeted at micro and small enterprises, as these companies may benefit from increased online engagement. Training in digital skills and marketing could help these businesses capitalize on their social media presence and translate it into tangible business outcomes.

Given that the digital presence of these companies is minimal, there could be substantial potential for market expansion and engagement through more consistent and strategic online marketing efforts. However, it should be noted that the survey doesn't indicate the industries these companies belong to, which could influence the relevance and impact of digital marketing for them.

2. DIGITAL MARKETING STRATEGIES THAT COULD BE USED TO PROMOTE FURNITURE MANUFACTURING MSMEs

To create an effective digital marketing plan, MSMEs must first identify clear strategic objectives that will guide all subsequent marketing efforts. Marketing specialists usually focus on building a pathway through the marketing funnel: helping target customers become aware of the brand/products that are being offered; cultivating an interest that would be transformed into a desire in the customer leading to action (conversion, sale), retention (post-purchase), and advocacy (satisfied customers recommending your company). Customers may hop between the different stages, however, it is up to the company to create opportunities to be seen at each of those.

From the survey, it becomes evident that many MSMEs are underestimating the importance of digital marketing for the growth of their business and overall profits. We’re going to analyse several strategies that could help MSMEs in the manufacturing sector improve their digital presence.

Content strategy starts first and foremost with the determination of the target buyer persona. Who is the ideal customer of the business? Is it interior designers that they’ll partner with, boutique businesses looking for unique solutions, or homeowners and renters who are interested in customized solutions for their furniture? It’s recommended that owners focus on one or two target customers while the company is growing and has more limited resources. Once it’s in a more secure stage of its development it can focus on more personas and expand its operational coverage.

Investing and regularly updating websites might be challenging for micro and some small companies, but they can create and regularly update their social media accounts at little to no expense. Small and medium companies that have enough budget should consider building a simple SEO-optimized website to showcase their products to potential customers.

After determining its target audience, the company should reflect on which social channels is their audience active and focus on them. With social media content being so similar (concerning the types of content used), the company can repurpose the same content with small changes to its different channels (Instagram, Facebook, TikTok).

The content should focus on what makes the brand/company unique compared to its competitors – what are unique selling posts, sustainability, bespoke services, local craftsmanship, promote the story behind the brand, and showcase the production process. The furniture manufacturers must focus on the customer as the hero in the content they create, not their products. They should explore how their offering helps alleviate the pains/issues that their target audience is going through related to furniture, rather than just showcasing the features of their products.

The content can be distributed in several content pillars – educational, inspirational, promotional, or engagement-driven content. Educational content can include Q&A sessions, and informational lives showing different aspects of the furniture-making process and why it's important to do things a certain way. Inspirational content can include finished furniture projects, before and after content, and videos with designers using the firm's products in their projects. Promotional content could be special pricing for a certain period, limited-time offers, announcements, and pre-order opportunities. Engagement-driven content includes interactive polls, quizzes, and contests on social media platforms centered around home décor themes.

REFERENCES

1. Chaffey, D., & Ellis-Chadwick, F. (2019): Digital Marketing (7th ed.). Pearson Education.
2. Kotler, P., & Keller, K. L. (2016): Marketing Management (15th ed.). Pearson Education.
3. Porter, M. E., & Heppelmann, J. E. (2014): How smart, connected products are transforming competition. Harvard Business Review, 92(11), pp. 64-88.
4. Smith, K., & Zook, Z. (2020): Digital transformation in the furniture industry: Challenges and opportunities. Journal of Industrial Innovation, 37(4), pp. 456-473
5. Iliev. I. (2023) Social networks and network management, in Trajectories of social development, 2023, UNWE editorial's complex, pp. 41-53, URL: https://www.ceeol.com/search/book-detail?id=1225113
6. Roupska, T., Jolovski, J., (2022): Appliance of Innovative Technologies in Managerial Accounting Models in Digitalized Accounting System, UNWE Researcg Papers (1), URL: https://doi.org/10.37075/RP.2022.1.10

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MANAGEMENT PRACTICES, INVESTMENT OPPORTUNITIES AND INNOVATIONS IN THE FORESTRY-BASED SECTOR

FORMATION OF "NEW FOREST SPACES" IN URBANIZED AREAS IN LINE WITH THE GREEN DEAL

Petar Marinov and Mihaela Mihailova

Abstract: Climate change has a vast global impact on the environment and is the core problem for food chain, human health, bio-habitats etc. The search for a new paradigm aimed at a change in the socio-economic state is imperative for bettering the life of all living things. The European Green Deal includes a comprehensive approach to improving urban and rural forest spaces. The current scientific research aims to present a new view to climate change, presenting a mathematical model for the formation of green areas in urbanized spaces as a solution of the presented problem. This paper attempts to present green spaces as an alternative solution to climate change, that has a diverse affect on urbanized areas (one of the objectives of the European Green Package). Urban forests play a crucial role in this strategy. Increasing interest in urban forestry is seen as an efficient nature-based approach to tackle challenges connected to urbanization and climate change. The creation and maintenance of urban forests align with recent EU policies, including the New Green Deal, the EU Biodiversity Strategy, and the EU Urban Agenda, underlining their importance in sustainable urban development.
Keywords: Climate change, green spaces, urban forests, Green deal.

INTRODUCTION

Global and local climate change is a fact that is object of discussion and research as the problem has worsen in the last decade and in a need for new policies, approaches and global restructuring of agriculture, manufacture and living is needed. As researchers the following question should be the focus of our studies: Is this change of climatic factors directly related to anthropogenic activity or is it another global cycle of the geochronological development of the planet? How can we implement small changes that can accumulate overtime instead of big changes that upend and disturb human life? The discussion about climate change began in the seventies of the XXth century and continues in the XXIst century, as the scientists working in this direction have not had a unified position related to the change over the decades. Some of them (Cook at al. 2016) suggest that anthropogenic influence is at the root of rising temperatures and CO_2 globally. Another part, a significantly smaller percentage of scientists (and their opinion should not be neglected) believe that global warming is a cyclical process related to planet Earth tilt cycles, changes in orbit and so on (Lawrence, 2011, Plait, 2012 & Sheppard, 2012).

The implementation of the European Green Deal emerges as a great ambition to turn Europe into the first climate-neutral continent by 2050. The changes that will take place in all sectors of the socio-economic development of the member countries until the above-mentioned year, "lean" on the new ecological paradigm will decrease carbon dioxide to the levels of the nineties of the twentieth century (Yarkova, Y. & Mutafov, E. 2017).

The formation of "Urban Forests" as a concept of socio-economic importance as continuation of the European Green Policy. According to the authors, the basis for this definition should be sought in the formation of an idea for a new type of settlement "Garden Cities" (Caves, 2014, Howard 1902), in which a certain territory of them (40%) should be covered by green infrastructure. This type of cities began to be built in the 1950s in England. The first declared such "new town" was Cumbernauld in Scotland, opened on 9/12/1955. The second such area is Runcorn, an area of Cheshire in north-west England, declared a "garden town" type in 1963. During the period 1945-1960, 15 new "garden cities" were formed in England, and a further 17 were formed within the next ten years from 1961 to 1971. The cities of Milton Keynes from 1960 and Redditch from 10.04.1964 are cities where the philosophy of "garden cities" is successfully applied (Radovanova, 2021).

The construction of green areas (new forest areas) in urbanized areas and in less populated areas (rural areas) within the borders of the EU in the coming decades will be of key importance for the implementation of the European Green Deal presented above. Based on the facts stated above, the authors offer their view, by forming "new forest spaces" in settlement structures, through a mathematical model, without pretensions to comprehensiveness and final formulation of the idea.

MATERIALS AND METHODS

The presentation of a theoretical mathematical model in the scientific development aims to present the construction of forest spaces in the urbanized areas in a percentage ratio in relation to the area of the settlement and the number of the population, meeting the socio-economic needs of the society (Marinov, 2023).

$$\mathbf{D = P \times (F + M) \quad \leftrightarrow \quad Z = (G - D) / G \times 100}$$

Where:

G - Settlement area 7 km²
P – Population in settlement 50 000
F - Living area per person 25 m²
M - Infrastructure area per person 50 m²
D - Total infrastructure area per person
Z - Required forest area in (percent %) for the settlement

In the development of the theoretical mathematical model, a mathematical methodology (Dokuzova, et al., 2014), a historical review, a geographical approach and a comparative analysis was applied in the scientific development of forest spaces in urban areas. The methodology proposed by the authors is applicable to all settlement structures within the borders of the EU. It has an open character, it can be supplemented or changed (socio-economic parameters), depending on the goals for its application. Microsoft Word and Excel were used in the research and analysis of statistical information.

RESULTS AND DISCUSSION

In the theoretical methodology embedded in the model, we assume that the area of the relevant settlement is 7 km² (the indicated km² are an example number), inhabited by 50 000 inhabitants (the number of the population may change). The authors found that the living area per person should be 25 m² and the infrastructure area per person 50 m², (administrative, road, underground and all kinds of similar areas). For the corresponding mathematical model, we look for the required total infrastructure area per person in km² or:

50 000 x 75 = 3 750 000 m² ↔ 3 750 000 / 1 000 000 = **3,75 km²**

Therefore, after finding **D – Total infrastructure area per person 3,75 km²**, the theoretical mathematical model, attempts to find **Z – Required forest area in (percent %)** for the settlement, or:

Z = (7 – 3,75) / 7 x 100 = 3,25 / 7 x 100 = 0,46 x 100 = 46%

Accordingly: Z - necessary forest area for the respective settlement is 46% of the total area of the same.

When developing the mathematical model, the number of the population of the respective settlement is accepted, as well as the numerical values for the different types of infrastructure, which can be variable, respectively: **20 m² ≤ F ≤ 45 m² and 45 m² ≤ 70 m².** The change of each of the indicators mentioned above will lead to a change in the values related to **D and Z**, which allows the proposed model to be applicable to any changes in the numerical indicators.

What is the need for **"New Forest Spaces"**? As part of the evolving human civilization, on Earth, we must know that the forest, as a biological and at the same time physical dimension, has a key role for human survival globally and there lack has local social impact. The very formation (natural or artificial) of forest spaces, regardless of where and when, constitute an eco-system combining all the necessary elements for the existence and prosperity of society. It is the only resource without which the human population cannot exist and the only one known to be found only on planet Earth. The creation of "new forest spaces" combines the socio-economic element and is at odds with development. Trees are the main mechanism for air purification, specifically in this case in urbanized spaces. On the other hand, forest spaces have an impact on a local level by forming a micro climate in a certain territory, reducing the noise and warmth level during the warm months of the year, absorbing dust particles up to 75%, assimilating carbon dioxide to a large extent and a number of other benefits for people. The construction of new forest spaces in the settlements, through the benefits listed above, help preserve the health of the population living in them. The experience gained in preparing the strategy for forests in England is based on four main principles: quality, integration, partnership and community support. The presentation of this kind of "policy" can be applied as a basis for the development of the formation of "new forest spaces" in the created urbanized areas. In modern settlements, the use of four types of forests can be applied, which have a direct impact on the quality of life in a certain territory for the corresponding number of the population inhabiting the areas: 1) Forests with an economic purpose; 2) Forests for regeneration and economic recovery; 3) Forests with public benefit, recreation and tourism; 4) Forests for nature protection and environmental protection, (Forestry Commission, 1998). The formation of forest spaces in urbanized areas should not be considered as independent infrastructural units, but as part of the general space of the area.

Global and local temperature changes are a basic indicator of climate change. Before we start to analyze the climatic changes of Earth (base period 1960-1990), we should know that the collection of statistical information about the above-mentioned processes began at the beginning of the 20th century in connection with the development of aviation. According to (IPCC, 2021) …"the rate of increase has been particularly high since 1970 at about 0.2°C per decade. During this period, global temperature has risen faster than in any other 50-year period for at least 2,000 years, with the last 8 years (2015–2022) being the warmest on record." The facts are indisputable, but one should also not ignore the other side of the argument, where a small scientific community, who are engaged in the study and study of climate processes, that think the change in the global climate picture in the last approximately 100 years is due to a cyclicity associated with with the planet and the influence of solar processes (eruptions). In order to prevent serious environmental shocks on a global and local level, in particular for the continent of Europe, all signatories of the United Nations Framework Convention on Climate Change committed themselves in the Paris Agreement: from 2015 to limit the increase in global temperature to well below 2°C above pre-industrial levels (1960-1990) by 2050 and towards efforts to limit the increase to 1.5°C. A fact to be noted here is that during the actual Pre-Industrial period 1850-1900, the collection of statistical information on climate processes was sparse, with little data most likely inaccurate or local to certain seasons or years. During this period of time, the technological processes related to research and collection of statistical information about climatic phenomena did not have great precision.

According to (Masson-Delmotte, V. & Zhou, B., 2021) …" Europe is warming faster than the global average. The average annual temperature over European land areas in the last decade has been 2.04 to 2.10°C higher than in the pre-industrial period. 2020 was the warmest year in Europe since the beginning of instrumental records according to all datasets used, with an anomaly range between 2.53°C and 2.71°C above pre-industrial levels. Particularly strong warming is observed in Eastern Europe, Scandinavia and in the eastern part of the Iberian Peninsula". Industrial processes and the high concentration of urbanized spaces have a direct impact on climate change, both locally and globally. The formation of "new forest spaces" in the settlements of the Old Continent is likely to have an impact on the climatic processes and a favorable impact on the socio-economic processes. This will not be a "Panacea" to the problem, but combined with the necessary measures and controls, the rise in temperatures and carbon dioxide can be slowed down and air quality and quality of life can be improved. Going into specifics for Bulgaria in rural areas (Mutafov, 2021) in this direction, farmers can be encouraged to form new fruit species (preserving the old ones) responding to climate changes.

The new guidelines for environmental policy - EU Green Deal targets by 2050, a climate-neutral region, such as reducing greenhouse gas emissions by 2040 and returning to 1990 levels, as well as compliance with the 2015 Paris Agreement year. In order to achieve the ambitions set by the Community, it is necessary to apply the relevant requirements: 1) full implementation of the existing EU laws on environmental norms; 2) decarbonize the industry; 3) increasing domestic production in the field of new technologies; 4) preservation of justice, solidarity and social policies towards all socio-economic sectors and regions in the EU and 5) open dialogue with all stakeholders, including agricultural producers (all branches and EU countries), enterprises (from all socio-economic sectors), social partners and citizens.

The authors of the scientific publication are subject to (EC priorities-2019-2024) …"legally binding climate targets: Target to stimulate natural carbon sinks". The formation of "new forest spaces" in the urbanized settlements and rural areas of the EU, on the one hand, has a social effect for all the inhabitants of these areas, on the other hand, it supports one of the objectives of the EU related to the implementation of the Green Deal and, last but not least, the creation and maintenance of green spaces within the borders of Europe has a purely humanitarian aspect.

CONCLUSIONS

Climate change is an undisputed reality for the citizents of the planet. A large part of the people (scientists and researchers) who deal with this matter do not have a clear idea why there has been an increase in the average temperatures of the atmosphere during the last century or if it is combination of factors (some of wich that can be influenced by us and some not). There is no consensus on this delicate issue. The models that are used to assess climate state and evolution are based on data embedded in them for a short period of time (last 60 years). In the geological development of the globe and the accompanying cyclicity of change affecting Earth, there have been several periods with drametic climate change. Climate change and its accompanying elements are not a paradox for our planet. The increased anthropogenic activity in all its forms is a fact, but it cannot be the main cause or only cause of climate change in a global aspect.

The imposition of various Green policies related to the reduction of harmful emissions in the atmosphere in the future will have an impact on the life of society and in our opinion drastic policies should be met with caution. Replacing conventional fuels is not a panacea for climate change. The search and imposition of a new paradigm related to climate change in the future is extremely important and necessary for the society of the planet. The green policy imposed in the EU countries has its advantages and most likely for the moment various types of activities can be limited, but in the future this type of policy will undergo changes.

According to the authors, at this stage attention should be paid to green spaces, both in urbanized spaces and outside them as well as forest preservation, green infrastructure creation and revitalizing city spaces. Considering the green areas or forests in the settlements to occupy a certain percentage of the territory will greatly ease the life of the society in these spaces. The ratio between the number of the population and the green spaces presented in the form of forest resource potential appears as one of the most important factors on which the entire model is built. New forests in urbanized spaces are essential for regulating the local climate: they reduce the force of winds, control water flows in horizontal and vertical directions, filter air and sunlight. It is unlikely to solve the global problem of climate change or melting glaciers, but it is a positive practical step towards enriching the forest background locally and globally.

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REFERENCES

1. Caves, R. W. (2004). Encyclopedia of the City. Routledge. p. 281.
2. Cook, J.; Oreskes, N.; Doran, Peter T.; Anderegg, William R. L.; Verheggen, Bart; Maibach, Ed W.; Carlton, J. Stuart; Lewandowsky, S.; Skuce, G.; Green, A.; Nuccitelli, D.; Jacobs, P.; Richardson, M.; Winkler, B.; Painting, R.; Rice, K. (2016): "Consensus on consensus: a synthesis of consensus estimates on human-caused global warming". Environmental Research Letters. 11 (4).

3. Dokuzova, I.; Razpopov, D.; and Dzhelepov, G. (2014): Three-dimensional Riemannian manifolds with circulant structures, Journal reference: Advances in Mathematics: Scientific Journal. vol. 7(1): pp. 9-16.
4. Howard, E (1902), Garden Cities of To-morrow (2nd ed.), London: S. Sonnenschein & Co, pp. 2–7.
5. IPCC, Climate Change (2021): The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, NY, USA.
6. The Forestry Commission publishes a wide range of information in support of sustainable forest management in Britain (1998) https://www.thenbs.com/PublicationIndex/documents/details?Pub=FC&DocId=295658
7. Lawrence, P. (2011): The Inquisition of Climate Science. Columbia University Press.
8. Marinov, P. (2023): Mathematical model for the formation of settlements based on forest and Green infrastructure, 16th International Scientific Conference WoodEMA 2023, 14-16.06., Prague, Czech Republic - Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy, pp 133-137.
9. Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, SL.; Péan, C.; Berger, S.; Caud, N.; Chen, Y.; Goldfarb, L.; Gomis, MI.; Huang, M.; Leitzell, K.; Lonnoy, E.; Matthews; JBR; Maycock, TK.; Waterfield, T.; Yelekçi, Ö.; Yu, R.; and Zhou, B. (2021): Summary for Policymakers', in: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.3. https://www.eea.europa.eu/en/analysis/indicators/global-and-european-temperatures?activeAccordion=ecdb3bcf-bbe9-4978-b5cf-0b136399d9f8
10. Mutafov, E. (2021): Regional Development and Cohesion Policy of EU 2021-2027. Trakia Journal of Sciences, Vol. 17 (1): p. 85.
11. Plait, P. (2012): "Why Climate Change Denial Is Just Hot Air".
12. Radovanova, P. (2021): Sustainable urban development. Sofia. ed. New Star.
13. Sheppard, K. (2012): "CHART: Only 0.17 Percent of Peer-Reviewed Papers Question Global Warming". Mother Jones.
14. The European Green Deal Striving to be the first climate-neutral continent https://commission.europa.eu/strategy-and-policy/priorities-2019- 2024/european-green-deal/delivering-european-green-deal_bg
15. Yarkova, Y. and E. Mutafov (2017), Rural Areas in Bulgaria–Investigation on some Factors for Development, Eastern European Countryside 23 (1): pp. 51–70.

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INVESTMENT AND INNOVATION SUPPORT FOR DEVELOPMENT OF THE FOREST INDUSTRY

Renata Nováková , Olena Plaksiuk, Eva Habiňáková

Abstract: Investment and innovation support for the economic development of forest resource potential is a set of methods, tools and levers of financial support for modernisation, reconstruction, renewal and technical re-equipment of fixed assets of forestry enterprises, as well as the introduction of modern technologies of forestry and forest protection. One of the distinctive features of innovation and investment support for the development of the forestry complex is that its main links, which are state forestry enterprises, include both forestry and wood processing. Successful achievement of sustainable forest management will provide integrated benefits for all, ranging from the social value of protecting livelihoods, biodiversity and ecosystems provided by forests, to increased income from the use of forest resources and forest products by economic agents. Therefore, the justification of priorities for investment and innovation of forest resource potential is an important component of state policy at the current stage of development of the national economy.
Keywords: investment, innovation, investment attractiveness, economic development, management

1. INTRODUCTION

Today, there is a tendency for forestry to be unattractive to investors, which hinders the development of the forestry sector. Investors want to get benefits quickly, which is impossible for this industry. When making investments in forestry, it is necessary to take into account the complex effect that is generated by investing in the reproduction of forest resource potential. Unlike other sectors of the economy, forestry generates significant positive environmental and social effects that can significantly exceed the economic effect. This makes the forestry industry extremely important for society in terms of creating favourable living conditions, the positive impact of forests on the environment, etc.

2. KEY PROBLEMS OF MANAGEMENT EFFICIENCY IN THE FOREST SECTOR

The problem of the financial mechanism of the investment environment of the forest resource sector, ensuring the investment development of forestry, and studying the investment potential of forestry production was studied by such scientists as: V. Golyan (2010), T. Melnyk (2011), Moravčík (2012), Konôpka (2010, 2012), Krečmer (1993), Papanek (1978), Anderson F., Angelstam P., Feger K.H. et al (2005) and others.

Papanek, (1978) argues that the key problem of society's attitude to forests has been expanded to include ensuring their existence not only as timber producers but also as sources of other vital (non-productive) goods. Until recently, the prevailing view was that if forests are optimally favourable from the production side, they also perform non-production functions. Today, this opinion is no longer valid. This is due to the fact that society's demands on forests to perform non-productive functions tend to increase (Moravčík, M., Konôpka, J. et al., 2012).

Today, in terms of management efficiency, there are a number of problems in forestry that hinder the development of the forestry sector of the national economy, namely:

- imperfect distribution of management functions, which in some cases leads to duplication of functions or loss of their performance;
- imbalance of financial support for forestry activities, lack of adequate funding for forestry and shortage of relevant specialists;
- lack of new economic mechanisms to stimulate the introduction of nature-saving technologies or their elements, protection, and expanded reproduction of forests, including on private property lands;
- the unsatisfactory state of ensuring the use of forests by citizens for recreational purposes, and many others.

In this regard, there is a need to develop a system of investment and innovation management that would ensure the practical implementation of the forestry development strategy.

3. NEW APPROACHES TO IMPROVING INVESTMENT POLICY

Improving investment support for the implementation of forestry projects depends on increasing their investment attractiveness and improving certain components of the national forest policy, which create favourable credit and tax conditions for financing the reproduction of forest resource potential. The investment attractiveness of the forestry business, especially for foreign investors, can be increased by actually implementing elements of modern ecological management that have long proven effective in developed countries.

The main step in the system of measures to improve the investment policy in the field of forestry production should be the improvement of the investment climate by implementing internationally proven management methods in domestic practice, streamlining the national market of forest products and encouraging forestry enterprises to increase investment in building up forest resource potential. The fundamental point of the new model of investment activity in the forestry complex is the elimination of the rent attractiveness of the economic development of the forest resource base and the direction of the investment activity vector to the integrated processing of wood. In today's business environment, an extremely important factor in the effective operation of enterprises is their resource potential, the rational use of which determines the achievement of a balanced development of each sector of the country's economy. Among the components of resource potential, human capital plays a significant role. Therefore, the issue of investing in human capital as the main source of development of the national economy, quality of work and life of the population remains particularly relevant (Plaksiuk, Nováková, Habiňáková, 2022).

The orientation of the national economy towards the priorities of the world market includes the development and formation of new approaches to the greening of economic activity of enterprises based on a combination of administrative, economic and financial management methods. This will include the possibility of improving the models of regional functioning through the formation of financial mechanisms that would ensure the efficient use and reproduction of the natural potential of each territorial complex. Improvement of the financial mechanism is an essential condition for ecologically balanced forest management, since the imperfection of the existing financial mechanism for the use and reproduction of forest resources is a constraint to the effective development of the forest sector. Due to the unsatisfactory state of the country's forest fund and the growing demand for the ecological and economic functions of forests, the forestry development strategy should be aimed at environmentally balanced management principles. Important tasks include expanded reproduction of forests, their protection, greening of production and economic instruments, as well as the spiritual sphere and people's consciousness. At the same time, ecologically balanced forest management involves the integrated, rational use of forest resources, continuous improvement of their economic, environmental and social functions, taking into account environmental imperatives to meet the needs of present and future generations.

An important factor in sustainable forest management is the financial mechanism, which should be environmentally oriented due to the special importance of forest resources in the environmental and economic sphere. In turn, the financial mechanism includes legal, information and regulatory support, financial levers and incentives. The levers include: 1) payment for special use of forest resources; 2) investments; 3) credit; 4) land and other taxes; 5) forest resource funds; 6) fines for violation of forest legislation; 7) rent; 8) leasing; 9) insurance payments; 10) prices; 11) plans; 12) others. Incentive methods include: 1) preferential taxation; 2) preferential lending; 3) differentiation of customs rates depending on the degree of processing of timber products; 4) budget financing; 5) pricing; 6) environmental insurance; 7) planning; 8) investment; 9) others. Support: 1) legal (resolutions, laws, etc.); 2) information (reporting of enterprises, etc.); 3) regulatory (instructions, norms, standards).

The main sources of funding for forestry are the enterprises' own funds, state budget funds, and loans. Table 1 shows the financial results and state support of the forestry industry in Slovakia over the past ten years. Budgetary funds are allocated for forestry operations, forest protection, control of forest pests and diseases, logging related to forestry, etc. However, budget funds are allocated in insufficient amounts and on a residual basis, without taking into account the priority of certain activities. Given the low forest cover and the predominantly ecological importance of Slovakia's forests, the state should continue to invest in protected forests, reforestation of land unsuitable for agriculture, etc.

The analysis shows that the industry's profit growth is several times higher than the state support for the forestry sector. In particular, there is a significant decrease in state support for the business sector (-62.5% over the past three years).

Therefore, it should be noted that the prospects for the development of the forest resource sector are associated with the intensification of public-private partnerships, which will not only attract additional financial resources for the modernization and creation of new modern industries, but also increase the level of innovation activity, which will contribute to the introduction of environmentally friendly, energy-efficient and resource-saving technologies at all stages of the movement of raw materials and products (Holian , Demydiuk , 2010).

The full development of any part of the economic complex in the context of economic policy liberalization and institutionalization of various forms of entrepreneurial activity is impossible without a developed market infrastructure, where financial and credit institutions play a leading role. Forestry is no exception. Moreover, the preliminary analysis (Table 1) of direct state subsidization and subsidization of forestry activities proved the need to diversify sources of financial support for forestry and forest protection activities. Time requires the spread of various forms of capitalization of the timber component of productive forces, and a positive solution to this problem directly depends on the effective operation of financial and credit institutions in the forestry sector. Given that forestry activities are not as attractive for investment as, say, ferrous metallurgy, in the near future, financial institutions will not be particularly active in financing forestry projects unless radical changes are made in the institutional system of financial and credit regulation of forestry.

Table 1. Selected financial and economic indicators of the forestry industry in Slovakia

2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2022/ 2013, %
Economic result (profit, loss). Total, mill. EUR										
95,40	77,92	25,51	28,62	40,62	44,45	44,59	44,72	51,62	31,53	202,57
including : Economic result (profit, loss). State forests, mill. EUR										
20,99	16,97	1,06	4,75	7,76	10,53	9,37	11,45	13,30	9,00	133,2
Economic result (profit, loss). Non-State forests, mill. EUR										
67,33	55,04	18,93	19,28	27,89	33,92	35,22	33,27	38,32	22,53	198,85
Economic result (profit, loss). The business sector, mill. EUR										
7,08	5,91	5,52	4,59	4,97	-	-	-	-	-	42,45
Total state support, mill. EUR										
24,19	28,93	39,44	36,80	38,40	51,55	24,38	55,41	17,39	15,40	57,08
including : State support State forests, mill. EUR										
10,53	8,26	12,30	12,73	13,06	35,79	5,14	10,56	4,61	4,35	142,07
State support Non-State forests, mill. EUR										
12,16	18,87	23,14	24,07	25,34	15,76	19,23	44,86	12,78	11,05	10,05
State support Business sector, mill. EUR										
1,50	1,80	4,00	-	-	-	-	-	-	-	-62,5

All of the above problems create an unfavourable climate in this area. Increasing the investment attractiveness of forestry enterprises can be achieved through environmental certification of forests and forestry supply chains, which will contribute to the growth of its competitiveness both in the domestic and foreign markets (Melnyk , 2011).

4. INVESTMENT DIRECTION OF THE NATIONAL FORESTRY PROGRAM SR 2022 – 2030

The planet loses 12 million hectares of forests every year. In 2013, the United Nations approved a program to create 300 million hectares of forests, 60 million in the United States and 70 million in China. Today, there are 360 points of view on the forest management system in the world, and Slovakia is no exception. The National Forestry Program SR 2022 - 2030 (NLP SR) indicates that the main problems of forestry do not exist in isolation, but rather in mutual interaction. They are interconnected, intertwined, complementary and influential. This fact is based on the fact that forestry is a broad field of human activity that is associated with maintaining and improving forests and providing benefits to owners and society. Forests are multifunctional, meaning that they not only have economic potential in the country, but are also an essential component of the natural environment, an indispensable stabilizer of the country's balance; they have multiple landscape, cultural, social and environmental significance. They are a source of timber, provide recreational opportunities and habitat for wild plants and animals, protect water sources and soils, and capture air pollution. They support employment, traditional land use, and biodiversity. Forestry is one of the main components of sustainable development of society, especially rural areas, ensuring quality of life through environmentally sustainable and socially inclusive growth.

One of the fundamental problems of forestry is the negative effects of the financial and economic crisis, current minimal political support, low social acceptance, inadequate technology and infrastructure, and lack of innovation. There are also long-standing problems of the non-state sector, primarily related to complex processes of forest land ownership. On the other hand, the current energy crisis, rising energy prices and possible energy shortages put wood in the position of a strategic raw material with the possibility of being used as an alternative source (Narodný lesnícky program, 2021).

The National Forestry Program of the Slovak Republic is the main forestry and policy document, an important tool for ensuring sustainable forest management, interagency cooperation and fulfilment of international forestry-related obligations. The program provides indicative financial support to channel investments from separate sources, as described in Table 2.

Table 2: Estimated financial limits of the NLP SR for 2022 - 2030

Strategy numbers	Estimated amount by individual ministries, in thousand EUR			
	MPRV SR	MŽP SR	MF SR	MIRRI SR
Strategy 1	60600	0	0	0
Strategy 2	59020	500	0	0
Strategy 3	6810	5580	0	0
Strategy 4	14100	50000	0	15000
Strategy 5	22	22	0	0
Strategy 6	290	150	0	0
Strategy 7	0	0	0	0
Strategy 8	45000	0	0	0
Strategy 9	28800	12750	0	0
Strategy 10	5300	0	0	5600
Strategy 11	100	34,50	0	0
Strategy 12	35500	0	0	0
Strategy 13	7525	7000	0	17600
Strategy 14	1265	250	0	0
Strategy 15	300	0	0	0
Strategy 16	112447	54822	40600	0
Strategy 17	1600	0	0	0
Total	378679	131108,5	40600	38200

In addition to the above-mentioned innovative measures, a prerequisite for the successful development of the state's forestry sector is the elimination of existing contradictions between forestry and the forest industry, the development of integration processes in the field of logging, protection and use of forest resources on the basis of lease relations and mutual interest in organizing sustainable forest management. It is the unsatisfactory level of investment and innovative renewal of the production and technical base of the forestry sector that causes the cost of competitiveness of the national economy, namely the decline of fixed assets, a decline in production and an increase in production costs, which in turn exacerbates the problem of investment resources. The NLS is developed taking into account the need for a unified state policy in the field of forestry, changes that have occurred in forestry in recent years and Slovakia's international obligations. Taking into account the above-mentioned directions aimed at the effective development of forestry, the industry will be able to overcome the systemic crisis. Further development and implementation of the innovative concept of sustainable forest management will help to increase the level of forest cover and have a positive impact on the economy as a whole.

REFERENCES

1. Anderson, F.; Angelstam, P.; Feger K.H. et al. (2005): A research strategy for sustainable forest management in Europe. Technical Report 5, COST Action E25. ECOFOR, Paris, 2005. 166 p.
2. Holian, V.; Demydiuk S. (2010): Public-private partnership is an effective form of entrepreneurship in the forest sector. *AgroSvit*. *15.*pp. *2–9*.
3. Konopka, J. *et al*. (2010): Krizovy manažment v lesnom hospodarstve. Zvolen, NLC, 74.
4. Krečmer, V. (1993): Trvale udržitelny rozvoj a lesni hospodařstvi v ČR (I). *Lesnictvi – Forestry*, 39(12): 513-519.
5. Moravčík, M.; Konôpka, J. *et al*. (2012): Key issues of forestry, wood-processing industry and hunting – addressing them and proposals. *Lesnicky časopis - Forestry Journal,* 58(4): 211–223, 2012, ref. 15, ISSN 0323 – 1046.
6. Melnyk T. D. (2011) The mechanism of increasing the investment potential of the forestry complex of the region*]. Bulletin of the National University of Water Management and Nature Management. Economics Series. 4 (56). 181–186*.
7. Moravčík, M.; Konôpka, J. *et al*. (2012): Key issues of forestry, wood-processing industry and hunting – addressing them and proposals. Lesnicky časopis - Forestry Journal, 58(4): pp. 211–223, 2012, ref. 15, ISSN 0323 – 1046.
8. Plaksiuk, O.; Novakova, R.; Habiňáková, E. (2022). Investment in human capital as a guarantee of the country's economic development in woodworking industry. *Crisis Management and Safety Foresight in Forest-Based Sector and SMEs Operating in the Global Environment.* ISBN 978-953-8446-00-9.
9. Narodny lesnicky program Slovenskej republiky pre obdobie rokov 2022 – 2030: (2021) URL: https://www.mpsr.sk/aktualne/oznamenie-o-strategickom-dokumente-narodny-lesnicky-program-sr-pre-obdobie-rokov-2022-2030-lesy.

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READINESS OF WOOD PROCESSING ENTERPRISES IN SLOVAKIA TO IMPLEMENT CHANGES

Andrea Janáková Sujová, Petra Lesníková

Abstract: Current changing business environment forces the enterprises to be able perform changes anytime and to be agile. The success by implementation of changes mostly depends on a favourable background for its realization. Most of success factors are common and relate to human factor, learning and communication activities during implementing changes. The aim of the paper is to assess the readiness of wood-based enterprises in Slovakia to make changes in the company. The quantitative primary research through questionnaires was conducted to find out the attitude to changes and to assess the status of internal environment in relation to success of change´s realization and ability to be agile.
Keywords: change management, agile enterprise, wood-based companies

1. INTRODUCTION

Changes in a business are essential for its growth and adaptation to a changing environment. However, it is important that these changes are properly managed and that employees are prepared to embrace them. According to research by McKinsey & Company (2018), only 37 percent of respondents reported successful change implementations. More recent research by Miller (2020) reports that approximately 50 percent of all organizational change initiatives are unsuccessful. These results highlight the importance of the skill to plan, coordinate and implement change in the enterprise. Organisational change is usually undertaken because of confidence in its effectiveness in the form of improved business performance. However, if change is managed incorrectly, it can lead to loss of productivity and poor employee performance (Stobierski, 2020).

Businesses should ensure that employees are ready for the change before it is implemented. It is evident that the relationship between employee readiness for change and the implementation of organisational change will be stronger when self-efficacy is higher. Self-determination theory (Rahi et al., 2021) is important in the present context, which suggests that both employees' performance and their well-being are influenced by the type of motivation they have for their work activities (Deci et al., 2017). The aforementioned also has a connection with how employees show helpfulness towards the organization. Focusing on employees' emotional attachment to change could be one way to increase employees' readiness for change (Soumyaja et al., 2015). Fatima et al. (2020) state that employees' readiness for change mediates the relationship between their change-related self-efficacy and commitment to change. This provides the basis for equipping employees with the necessary attitude and intention for successful implementation of the change process. However, sufficient awareness is a prerequisite. Michels and Murphy (2021) identified nine common traits and capabilities that help businesses excel at change. Specifically, these are: purpose, direction and connection (necessary for leading change); capacity, choreography and scaling (necessary for accelerating change); and development, action and flexibility (necessary for organising change). Understanding the strengths and weaknesses in these categories allows to determine change capability and develop a plan for scaling it up over time. At the same time, the authors found that a company's readiness for change is a strong predictor of its performance. This suggests that a firm's ability and readiness to implement change is undoubtedly an important component of business agility.

2. METHODOLOGY

The main method of the research was a primary quantitative research conducted from questionnaires. The research was focused on the management of changes in Slovak enterprises operating in wood-based sectors (WPI). The core sample size for the research was a database of 300 wood processing enterprises, out of which 82 respondents represent the research sample. According to the calculation of the minimum statistical research sample the research sample size of 82 respondents is a representative statistical sample with 92% confidence and 8% standard deviation. The questionnaire consists of 5 general, classification questions and 30 business-area management issues. In the paper, the results regarding the perceptions of changes in a companies are presented. The questionnaire was published online and the data collection was in 2018. Answers from the questionnaire have been evaluated by chosen statistical methods. We used descriptive statistics for one variable and PivotTables which combines the frequency distribution of two variables and represents an extension of a simple frequency table (Pacáková et al., 2018). The evaluation of the questionnaire was carried out using the software program Statistica 12 CZ - Stat Soft. Inc. (2013), while the imported database was created in MS Excel.

The aim of analysis of research results in the paper was to assess the readiness of Slovak wood processing enterprises to changes and their impelementation, as the basic prerequisite for building the agile enterprise.

3. RESULTS

The basis for the evaluation and analysis was an online database of questionnaire research results. Wood enterprises constituted the vast majority of our research, accounting for as many as 60 enterprises (73.17%), furniture enterprises accounted for 18 (21.95%), and pulp and paper enterprises accounted for only 4 (4.9%). The structure of the research sample of WPI enterprises by size and ownership is as follows. The survey was mainly micro and small enterprises with up to 50 employees. This category accounted for up to 85.36% of the enterprises, 7.3% represented large companies. In terms of business ownership, 83.9% of the enterprises are domestic or with predominantly domestic capital and ony 5% are foreign owned.

The perception of the management of changes and organizational process, which represents the transition from the current state to the future desired state, the attitude towards change and the awareness regarding the implemented changes were to be investigated in the context of assessing the readiness of people in WPI enterprises for change. Table 1 shows the results of the absolute and relative frequencies of this analysis. It can be seen that up to 90.24% of the enterprises consider change as an important factor in ensuring the success of the company. Only 5 enterprises, representing 6.10%, do not consider the need to make changes in order to ensure the success of the company. Change as a necessary evil and its negative perception by employees was reported by 3.66% of enterprises. From the answers to question

2 on the awareness of changes in enterprises, in 63.41% of enterprises all employees are informed about the changes and in 31.71% of enterprises only managers are informed about the changes. Awareness of changes in WPI enterprises is quite favourable as only 4 enterprises (4.88%) in the research sample reported that awareness in their enterprise is zero.

Table 1. Analysis of perceptions of change and level of awareness of change

Question and answers	n	%
1. How do you perceive the changes in your company		
Change is an important factor in ensuring a company's success	74	90.24
Changes in the business are not necessary for the success of the business	5	6.10
Changes are a necessary evil, negatively perceived by employees	3	3.66
2. What is the level of awareness of the changes in your company?		
Everyone is informed about the changes implemented	52	63.41
Only managers receive information about changes	26	31.71
There is almost zero awareness of the changes	4	4.88

Regarding the findings on attitudes towards change (see Figure 1), two thirds of the enterprises have a neutral attitude, stating that they are able and willing to adapt to new conditions and changes; in 12% of the enterprises the attitude is positive, where changes are initiated and supported. On the other hand, 21% of enterprises have a negative attitude towards change, of which fear of change is prevalent in 16% of enterprises and 5% of enterprises perceive change as a problem and evil.

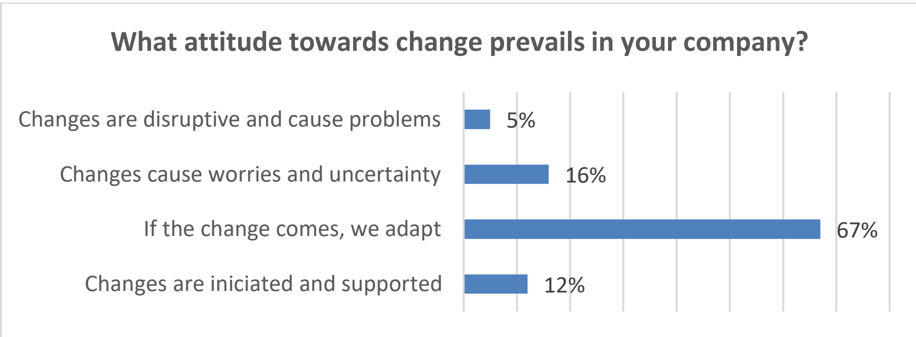

Figure 1. Attitude towards change in the WPI enterprises

Table 2 shows the results of the responses to the question that aimed to find out how WPIs are preparing for change. The results show that 15.85% of the WPI enterprises do not prepare the change, the remaining enterprises implement only one of the above steps, of which financial-economic evaluation of the proposed changes is predominant in one third of the enterprises, followed by defining the goal and resources for change in ¼ of the enterprises. A low number of enterprises analyse the baseline situation (17.07%), which may result in incorrect identification of necessary and possible changes. The smallest number of enterprises, below 5%, assemble a project team and prepare options or action plans to implement the change.

Table 2. Steps taken before implementing changes.

Description of answers	n	%
analysis of the baseline situation	14	17.07
identification of the changes needed and analysis of the change requirement	19	23.17
defining the objective and identifying the resources to implement change	21	25.61
setting up a project team and a change agent (team leader)	4	4.88
preparation of options for the change project and an action plan for the implementation of the proposed changes	4	4.88
financial and economic evaluation of the proposed changes	27	32.93
monitoring the effects of change	11	13.41
we do not take any of the above steps	13	15.85

In next question the responses relating to the analyses carried out in preparation for the changes were found out. According to the results, we can conclude that WPI companies perform 1.7 analyses, i.e. 1 to 2 analyses on average. Customer satisfaction and needs analysis achieved the highest number of responses in 45.12% of the WPI enterprises, followed by financial analysis, which is carried out by 43.90% of the WPI enterprises. Lower response rates were achieved for SWOT analysis in 4.88% and for force field analysis in 6.1% of WPI enterprises. The SWOT analysis and the force field analysis are analyses of the baseline situation. The low response rate for these analyses corresponds to the findings in the previous question that only a small number of enterprises pay attention to the analysis of the baseline situation when preparing for change. We were therefore interested in what types of changes enterprises predominantly implemented when they did not need to analyse the baseline situation. The relationship between the types of changes and the analyses carried out prior to their implementation is shown in contingency table 3.

Based on the data in Table 3, it can be concluded that financial analysis has a 68.75% percentage in enterprises that have implemented financial restructuring. Force field analysis led the WPI enterprises to transformational restructuring change with a response percentage of 25%. Reengineering change in manufacturing enterprises was implemented in 75% of the cases based on portfolio analysis. For incremental optimization changes, the impact of a combination of several analyses can be observed: in 55.10% the impact of customer satisfaction and needs analysis, financial analysis 46.94%, and competitive analysis 42.86%. Incremental changes in the enterprises were induced similarly to the previous group by the combination of several analyses. Based on the results, we can further conclude that there is a relationship between the analyses conducted before the change and the change that was implemented in the WPI enterprises. Needless to say, a combination of several analyses is used in companies, and there is always one or more that are dominant and ultimately influence the type of change implemented. The reason for the low share of analyses of the initial situation - SWOT analysis and force field analysis is the fact that most enterprises have implemented most small, optimization changes, or unplanned changes and changes in the financial area, when sub-analyses of a given area are sufficient. However, a force field analysis showing the readiness of employees to changes is underestimated.

Table 3. Contingencies of types of changes and analyses performed

Analyses carried out in preparation for the change	Type of change implemented						**SUM**
	Financial restructuring	Transformational change restructuring	Radical re-engineering change	Incremental optimisation changes	Incremental, i.e. unplanned changes	no changes	
SWOT analysis	*1 6.25%*	*1 12.5%*	*0 0.00%*	*1 2.04%*	*1 5.56%*	*1 5.56%*	*5*
Portfolio analysis	*3 18.75%*	*1 12.5%*	*3 75.0%*	*4 8.16%*	*1 5.56%*	*0 0.00%*	*12*
Force field analysis	*1 6.25%*	*2 25.0%*	*0 0.00%*	*2 4.1%*	*1 5.56%*	*1 5.56%*	*7*
Financial analysis	*11 68.75%*	*1 12.5%*	*2 50.0%*	*23 46.9%*	*5 27.8%*	*3 16.67%*	*45*
Competitive analysis	*4 25.00%*	*0 0.00%*	*1 25.0%*	*21 42.9%*	*6 33.3%*	*3 16.67%*	*35*
Analysis of business processes	*3 18.75%*	*0 0.00%*	*0 0.00%*	*9 18.4%*	*4 22.2%*	*1 5.56%*	*17*
Analysis of customer satisfaction and needs	*6 37.50%*	*4 50.0%*	*1 25.0%*	*27 55.1%*	*7 38.9%*	*5 27.78%*	*50*
Other (please specify):	*0 0.00%*	*0 0.00%*	*0 0.00%*	*1 2.04%*	*3 16.7%*	*6 33.33%*	*10*
SUM	*29*	*9*	*7*	*88*	*28*	*20*	*181*
Relative abundance	*16.04%*	*4.97%*	*3.87%*	*48.6%*	*15.5%*	*11.0%*	*100*

3. DISCUSSION AND CONCLUSION

Change management has received considerable attention in the professional community. This is reflected in the fact that 90% of the companies surveyed consider change management to be an important factor for success, which agrees with the research of Stobierski (2020). However, there are still some limitations in terms of employees' readiness for change and their attitudes. Despite the fact that in more than 60% of enterprises all employees are informed about the changes and 67% of enterprises perceive a neutral attitude towards changes, there are still enterprises in which a negative attitude prevails (21%) stemming mainly from fear. To some extent, it can be stated that employees' readiness for change in the form of change-related self-efficacy and commitment to change (as reported by Fatima et al. (2020)) is at a lower level in the WPI enterprises. Looking at the use of analyses, a low number of surveyed enterprises analyze the baseline situation (17.07%), which may result in misidentification of necessary and possible changes. WPI enterprises perform 1 to 2 analyses, with customer satisfaction and needs analysis and financial analysis predominating. Conversely, underutilized is the force field analysis, which can serve as an important tool for improving the enterprise's readiness for change by providing baseline information on the attitudes and perceptions of change in the enterprise and the perspective needed to create a favorable environment prior to implementing change.

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REFERENCES

1. Deci, E.L.; Olafsen, A.H.; Ryan, R.M. (2017): *Self-determination theory in work organizations: The state of a science*. Annual Review of Organizational Psychology and Organizational Behavior 4: pp. 19-43.
2. Fatima, M.; Riaz, A.; Hafiz, Z.; Mahmood; Usman, M. (2020): *Linking Employees' Change-Related Self-Efficacy, Change Readiness and Commitment to Change.* Pakistan Journal of Commerce and Social Sciences 14(1), pp. 334-367
3. McKinsey & Company (2018): *How the implementation of organizational change is evolving*. URL: https://www.mckinsey.com/capabilities/implementation/our-insights/how-the-implementation-of-organizational-change-is-evolving#/
4. Michels, D.; Murphy, K. (2021): *How good is your company at change?* Harvard Business Review. URL: https://hbr.org/2021/07/how-good-is-your-company-at-change
5. Miller, K. (2020): *5 critical steps in the change management*. Harvard Business School. URL: https://www.mckinsey.com/capabilities/implementation/our-insights/how-the-implementation-of-organizational-change-is-evolving#/
6. Pacáková, V., Labudová, V., Sipková, Ľ., Šoltés, E., Vojtková, M. (2018): *Statistical methods for economists*. Bratislava: Iura Edition, p. 411.
7. Rahi, S.; Alghizzawi, M.; Ahmad, S.; Munawar Khan, M.; Ngah, A.H. (2022): *Does employee readiness to change impact organization change implementation? Empirical evidence from emerging economy.* International Journal of Ethics and Systems 38(2): pp. 235-253. https://doi.org/10.1108/IJOES-06-2021-0137
8. Soumyaja, D.; Tj Kamalanabhan; Bhattacharyya, Sanghamitra (2015): *Antecedents of Employee Readiness for Change: Mediating Effect of Commitment to Change*. Management Studies and Economic Systems 2: pp. 11-25.
9. Stobierski, T. (2020): *5 tips for managing change in the workplace*. Harvard Business Review. URL: https://online.hbs.edu/blog/post/managing-change-in-the-workplace

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INNOVATIONS IN FURNITURE INDUSTRY ENTERPRISES: A CASE STUDY IN BULGARIA

Vyara Kyurova, Blagovesta Koyundzhiyska-Davidkova

Abstract: In a world associated with a rapidly changing technological environment and a dynamic economic environment, innovation is one of the main ways to achieve lasting success and competitive advantage. It plays a key role in the development of furniture industry enterprises. Innovations are also essential for promoting flexibility and sustainability in the implementation of business activities. Paying attention to the implementation of innovations enables the enterprises of the furniture industry to satisfy the demands of consumers, increase efficiency, productivity and income, reduce costs. Taking actions related to innovation allows, on the one hand, to solve complex business problems, and on the other hand, to achieve uniqueness and novelty in the implementation of the business process. The realization of more and diverse types of innovations contributes to the easier handling of the upcoming changes in the surrounding environment of the furniture industry enterprises. In this context, the aim of the present study is to analyse the state of enterprises from the furniture industry in terms of implemented innovations. To achieve the goal, companies from the furniture industry were surveyed using the convenience sampling method. The application of this method is appropriate because of its adequacy in terms of the specificity of both the subjects studied and the data to be obtained. Based on the results of the analysis, generalized conclusions were drawn.
Keywords: innovations, furniture industry, enterprises

1. INTRODUCTION

The furniture industry is becoming more and more important for the economic development of countries. It is no coincidence that it is defined as a huge global business (Boon Kwee, Thiruchelvam, 2012), which is under competitive pressure from the globalized economy (Medeiros et al., 2009). This type of industry is a low-tech sector where innovation is fundamentally based on adoption more than invention (Otero-Neira et al., 2009).

Innovations hold significant importance for furniture industry companies, being crucial for sustainable development amidst a rapidly evolving market. Consequently, they receive focused attention and are a top priority in Bulgaria, as outlined in the strategic document “Innovation Strategy for Intelligent Specialization”.

Innovations also play a key role in increasing the competitiveness of enterprises in the conditions of fierce competition. They contribute to improving competitive positioning and profitability (Guimarães et al., 2016). At the same time, innovations provide an opportunity to transform the economic state of enterprises (Guimarães et al., 2014, p. 452; Lii, Kuo, 2016) with a view to improving their results. Directing the efforts of enterprises to innovation is a prerequisite for competitiveness in domestic and international markets (Szostak, Ratajczak, 2009).

Innovations are pivotal in the operations of enterprises, playing a crucial role in the development and attainment of competitive advantages. Moreover, they are the basis for achieving competitive advantage (Cao, Hansen, 2006; Pérez-Luño et al., 2007). In addition, innovations aim at improving a firm's performance by gaining a competitive advantage (Ratnasingam et al., 2018).

That is why the authors' efforts are aimed at studying the state of furniture industry enterprises from the point of view of the innovations they have implemented. The research is based on a survey of the opinions of 93 representatives of companies operating in the furniture industry in the period November-December 2023.

2. LITERATURE REVIEW

Authors examining the issue related to innovation emphasize its important role for the successful development of enterprises. A number of studies have been devoted to this problem. They define the concept of "innovation" and discuss its distinction from different perspectives.

2.1. Defining the concept of innovation

The analysis of literary sources reveals that there is no unified opinion of the authors regarding the definition of the term "innovation". Nevertheless, a group of researchers is converging on a view of innovation as investment in R&D and technology (Dosi, 1982; Lev, 2001; Epstein et al., 2010). In more detail, Gault considers innovations as the result of the investment activity of enterprises and pays special attention to the fact that they are the materialized result obtained from invested capital in new technology, equipment, forms of organization of production, new methods of planning and analysis and others (Gault, 2018). Popova has a more specific view on the issue, which also starts from the position of an ongoing activity. She defines innovation as the result of creative activity related to the creation of innovations through the generation and transformation of spiritual values into material results of ideas (Popova, 2015, p. 139).

In the scientific literature, innovation is considered as a collective societal process with firms as the core actors in a networked social context (Köhler, 2008). Kautonen (1996) examines innovation specifically in the furniture industry also as a process, but of the dissemination of best practices for the use of capital goods and intermediate inputs. At the same time, the definition of innovation, in which it is defined not only as a new or improved process, but also as a product, a new marketing method or a new organizational method in business practices, workplace organization or external relations is widespread (OECD, Eurostat, 2005). This definition is related to the search for possibilities for the classification of innovations.

A more specific understanding of innovation is contained in the definition of Boer and During (2001), who see it as "the creation of a new product-market-technology-organization combinations". The vision of innovation by Darroch and McNaughton (2002), who consider it to be a necessary component for enterprises related to the possibility of remaining competitive, also deserves special attention.

2.2. Typology of innovations

Knowledge of the typology of innovations is also important for the representatives of the companies from the furniture industry. A review of the literature shows that there is a lack of unity in the classification of innovations. For example, Hovgaard and Hansen (2004), based on a cross-functional approach, distinguish three types of innovation: product, process and business systems. At the same time, Johne and Davies (2000) define product and process as the main types of innovation. These authors believe that the market innovations should be added to them. Technological innovations can also be added to the mentioned types (Köhler, 2008).

The classification proposed in the third edition of the Oslo Manual (OECD, Eurostat, 2005) deserves special attention, in which innovations are systematized as product, process, marketing and organizational. Biolcheva's opinion regarding the classification of innovations in the furniture industry is similar. She also argues that eco-innovations should be added to product, process, marketing and organizational innovations (Biolcheva, 2017).

3. RESULTS AND DISCUSSION

4.

The opportunity for innovations is of particular importance for sustainable development and increasing the competitiveness of enterprises in the furniture industry. With their help, they manage to develop new products, satisfy consumer needs, and gain better market positions. In this context, the results of the research show that more than half of the respondents (57.5%) implement innovations (see Figure 1).

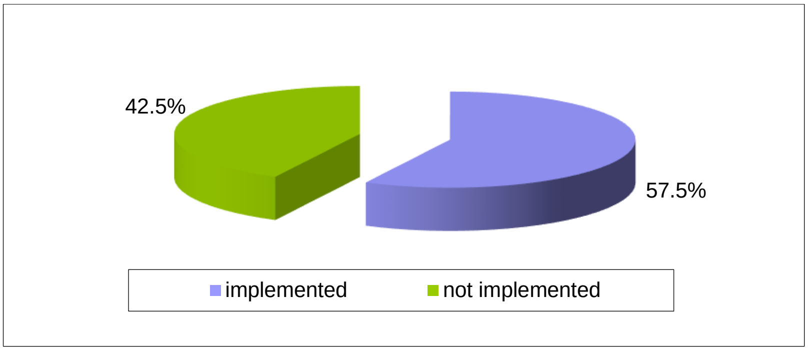

Figure 1. Distribution of enterprises according to the innovations made - %

It is noteworthy that a small part of them (8.6%) implement innovations once a year and over five years (9.8%). The share of those (15.7%) who make innovations in the range between three and four years is also not large. It was found that the representatives of the enterprises in the furniture industry who carry out innovations with a time span between one and two years predominate (23.4%).

The distribution of the innovations implemented by the enterprises of the furniture industry is also of interest (see Figure 2). The results of the survey show that respondents primarily focus their efforts on the development and implementation of product innovations (17.3%), followed by process innovations (13.9%). The share of realized organizational and management innovations (12.6%) and marketing (11.8%) is also not small. It is noteworthy that a small number of respondents are aware of the important role of green innovations contributing to the expansion of production opportunities. Proof of this is that only 1.9% of them implement eco-innovations.

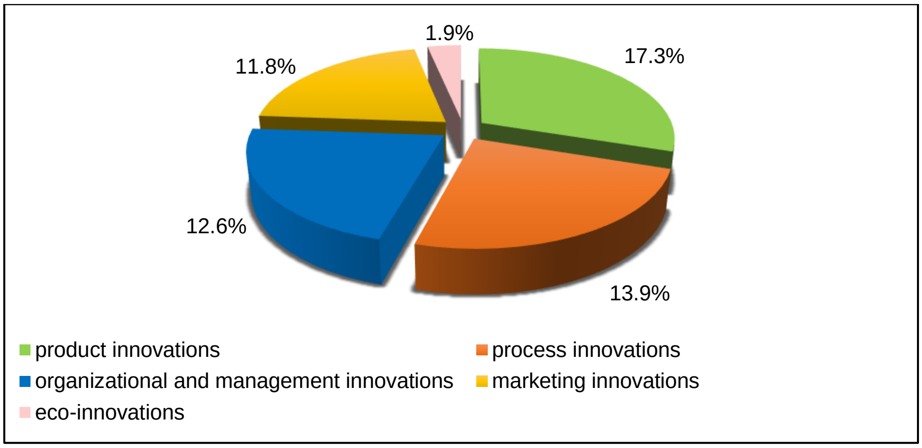

Figure 2. Distribution of enterprises according to the type of innovations - %

In terms of product innovations, the introduction of new products on the market takes priority (10.8%). At the same time, 6.5% of the respondents stated that they introduced new materials into production.

As for the implementation of process innovations, it was found that new or improved delivery methods occupy the smallest share (1.9%). The most implemented process innovations are related to new or improved production methods (8.4%), followed by new or improved additional activities (4.5%).

From the point of view of the implemented organizational and management innovations, it is noticeable that the enterprises direct their efforts to new organizational methods of work related to company culture and decision-making (7.1%). Also, the respondents have applied new organizational methods in their relations with other enterprises (5.5%).

Among marketing innovations, the application of new ways of advertising or promotional approaches (3.6%), followed by a new or improved product design or packaging (3.1%) takes a leading place. An important place is also occupied by new approaches used for product placement (2.7%), as well as new pricing methods (2.4%).

For an objective assessment, it is essential to identify the challenges that furniture industry enterprises encounter when implementing innovative practices. In this regard, the results of the survey show that the most serious problem is the provision of the necessary financial means for innovation (24.3%). As an important issue, they point out the slow return on the costs incurred for the implemented innovations (4.3%). A significant problem for the respondents is the lack of sufficient knowledge and experience in the field of creating innovative ideas, the very implementation of innovations, as well as the poor knowledge of patents and standards (17.5%). No less important problem shared by the respondents is the lack of a formed and functional active innovation policy (6.1%). The lack of partners for cooperation is also a barrier to creating and implementing innovations (5.3%).

4. CONCLUSION

Knowing the specifics of innovations adopted by enterprises in the furniture industry is a guarantee for achieving lasting market success and securing competitive advantage in an era marked by globalization and digital transformation. The continuous development of innovations manifested in the creation of new products, the enhancement and alteration of existing offerings, the penetration of new markets, the adoption of cutting-edge technologies, and the exploration of novel supply and distribution networks, is a fundamental cornerstone not just for sustainable growth but also for amplifying influence and achieving industry leadership.

The analysis of the innovations implemented by the enterprises in the furniture industry reveals that product innovations are the most preferred for creation and improvement. An important place in the innovation activity of these enterprises is occupied by both process and organizational and management innovations. The least represented are marketing innovations. Based on the fact that approximately half of the respondents do not implement innovations, it is indicative that they do not yet realize their importance as one of the main tools for achieving effective and long-term results.

The empirical research shows that enterprises in the furniture industry face serious difficulties of a financial nature, not having the necessary capacity in the field of innovation, not knowing the specifics regarding patents and standardization, not making the necessary efforts to develop an innovation policy, as well as not implementing of partnerships with other organizations. Their presence has a restraining effect on satisfying the need of the furniture industry enterprises for sustainable innovative development, allowing the increase of their competitiveness.

REFERENCES

1. Biolcheva, P. (2017): *Barriers before innovations in furniture companies.* Trakia Journal of Sciences 15(1): pp. 125-131.
2. Boer, H.; During, W. E. (2001): *Innovation, what innovation? A comparison between product, process and organizational innovation.* Int. J. Technology Management 22(1/2/3): pp. 83-107.
3. Boon Kwee, NG; Thiruchelvam, K. (2012): *The dynamics of innovation in Malaysia's wooden furniture industry: Innovation actors and linkages.* Forest Policy and Economics 14: pp. 107-118. https://www.sciencedirect.com/science/article/abs/pii/S1389934111001559
4. Cao, X.; Hansen, E. (2006): *Innovation in China's furniture industry.* Forest Products Journal 56 (11/12): 33-42.
5. Darroch, J.; McNaughton, R. (2002): *Examining the link between knowledge management practices and types of innovation.* Journal of Intellectual Capital 3(3): pp. 210-22.
6. Dosi, G. (1982): *Technological paradigms and technological trajectories. A suggested interpretation of the determinants and directions of technical change.* Research Policy 11: pp. 147-162.
7. Epstein, M. J.; Manzoni, J-F.; Dávila, A. (2010): *Performance measurement and management control: Innovative concepts and practices.* Emerald Group Publishing Limited, Bingley.
8. Gault, F. (2018): *Defining and measuring innovation in all sectors of the economy.* Research Policy 47(3): pp. 617-622.

9. Guimarães, J.; dos Reis, Z.; Severo, E.; Dorion, E.; Olea, P. (2014): *Implantação do Sistema Lean Production: Inovação Organizacional em uma Indústria Moveleira.* Sistemas & Gestão 9 (4): pp. 452-464. https://doi.org/10.7177/sg.2014.V9.N4.A4
10. Guimarães, J.; Severo, E.; Henri Dorion, E.; Coallier, F.; Olea, P. (2016): *The use of organisational resources for product innovation and organisational performance: A survey of the Brazilian furniture industry.* International Journal of Production Economics 180: pp. 135-147. https://doi.org/10.1016/j.ijpe.2016.07.018
11. Hovgaard, A.; Hansen, E. (2004): *Innovativeness in the forest products industry.* Forest Products Journal 54(1): pp. 1-8.
12. Johne, A.; Davies, R. (2000): *Innovation in medium-sized insurance companies: how marketing adds value.* International Journal of Bank Marketing 18(1): pp. 6-14.
13. Kautonen, M. (1996): *Emerging innovative networks and milieux: The case of the furniture industry in the Lahti region of Finland.* European Planning Studies 4: pp. 439-456.
14. Köhler, H. D. (2008): *Profit and innovation strategies in low-tech firms.* Estudios de Economía Aplicada 26(3): pp. 73-87.
15. Lev, B. (2001): *Intangibles: management, measurement and reporting.* Bookings Institution Press, Washington.
16. Lii, P.; Kuo, F.-I. (2016): *Innovation-oriented supply chain integration for combined competitiveness and firm performance.* International Journal of Production Economics 174: pp. 142-155. https://doi.org/10.1016/j.ijpe.2016.01.018
17. Medeiros, A.; Seibel, S.; Natal Jorge, R.; Fernandes, A. (2009): *Lean Thinking and Product Innovation in the Furniture Industry.* Proceedings of the ASME Design Engineering Technical Conference 8. https://doi.org/10.1115/DETC2009-86630
18. Ministry of innovations and growth (n.d.): *Innovation strategy for intelligent specialization,* p. 6. https://www.mig.government.bg/wp-content/uploads/2022/12/isis-2021-2027.pdf
19. OECD, Eurostat. (2005): *Oslo manual: guidelines for collecting and interpreting innovation data.* 3rd Edition.
20. Otero-Neira, C.; Lindman, M.; Fernández, M. (2009): *Innovation and performance in SME furniture industries.* Marketing Intelligence & Planning 27(2): pp. 216-232. http://dx.doi.org/10.1108/02634500910944995
21. Pérez-Luño, A.; Cabrera, R.; Wiklund, J. (2007): *Innovation and imitations as sources of sustainable competitive advantage.* Management Research 27 (2): pp. 216-232. http://dx.doi.org/10.2753/JMR1536-5433050201
22. Popova, R. (2015): *Innovations in the enterprises from the furniture industry*. Economic Studies 24(3): pp. 137-155.
23. Ratnasingam, J.; Ark, C.; Latib, H.; Subramaniam, H.; Khoo, A. (2018): *Innovation in the Malaysian furniture industry: Drivers and challenges.* BioRes 13(3): pp. 5254-5270.
24. Szostak, A.; Ratajczak, E. (2009): *Results of the innovation activity of the wood sector.* Drewno-Wood 52 (182): pp. 123-129.

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THE IMPACT OF QUALITY MANAGEMENT TOOLS, METHODS, AND APPROACHES ON THE ADAPTATION OF THE WOODPROCESSING INDUSTRY IN SLOVAKIA DURING TIMES OF CRISIS

Pavol Gejdoš

Abstract: The article addresses the impact of methods and tools within quality management systems on the performance of woodprocessing enterprises in Slovakia during times of crisis. The objective of this contribution is to ascertain whether, through effective quality management, a company can exhibit greater flexibility in adaptation and respond promptly to unforeseen changes. This investigation is conducted within the context of addressing the challenges presented by the COVID-19 crisis within the framework of woodprocessing companies in Slovakia.
Keywords: phasellus, vestibulum, tempor convallis

1. INTRODUCTION

In order to stay competitive in both local and international markets, it is crucial for companies to prioritize approaches rooted in quality management. Quality encompasses not just product attributes, but also production processes, management practices, and the overall reputation of the company. By maintaining high standards of quality across these areas, businesses can effectively address customer needs and achieve success. To ensure ongoing improvement in product quality and production processes, it is vital for enterprises to utilize quality management systems and adopt methods and tools for quality management. These approaches should be readily accessible and straightforward to implement. Consequently, the careful selection of suitable quality management procedures is indispensable for resolving issues related to subpar product quality. Modern organizations will emphasize the comprehensive utilization of principles, tools, techniques, and methods that foster societal development and continual enhancement. Through the application of quality management principles, industrial enterprises can attain success, providing a significant advantage during periods of crisis when adaptation to unforeseen changes becomes necessary. The objective of this study is to assess the current status of quality management systems (QMS) implementation and their potential advantages for enterprise management amidst crises within the wood processing industry in Slovakia.

2. MATERIAL AND METHODS

Numerous organizations have endeavored, and continue to do so, to find the most effective methods for translating quality management principles into daily operations. Globally, certain key concepts of quality management have emerged over time, forming the foundation for modern quality management systems. Over the past few years, three fundamental concepts have been identified, each varying in complexity and resource requirements, including personnel expertise (Nenadal et al., 2018). TQM operates on the premise that quality is a collective responsibility encompassing all facets of organizational operations. Universally, TQM has been embraced as a management strategy to bolster organizational performance and enhance competitiveness (Kuhn et al., 2018). TQM, however, is not rigidly bound by predefined rules; rather, it is an adaptable system that assimilates global best practices and tailors them to fit the organization's unique context (Albuhisi, A. M., and Abdallah, A. B.,2018). Numerous studies (Nguyen et al., 2018; Alharbi et al., 2017; Rebelo et al., 2016) corroborate the positive impact of implementing quality management systems on achieving sustainable development and elevating performance levels.The ISO concept represents the least demanding yet most widely adopted framework worldwide. According to Sarb et al. (2019) and Knop (2021), adopting the ISO 9001 quality management system is a strategic choice for organizations, offering potential enhancements to overall performance and establishing a robust foundation for sustainable growth. Su *et al.,* (2020) and Siltori *et al.,* (2020) underscore that ISO 9001 sets forth requirements for organizations seeking to consistently deliver products in compliance with relevant standards and customer expectations, thereby aiming to enhance customer satisfaction. The second concept revolves around industry-specific standards, which are tailored to reflect the unique characteristics of particular sectors. These standards typically incorporate the foundational principles of ISO 9001 while also delineating industry-specific requisites..

3. RESULTS AND DISCUSION

To determine the minimum sample size, a formula for the finite population according to Yamane Taro (Lind, 2020) was applied. With a target population size of 2,504 units and the selected error e=0.05 was the minimum sample size derived as:

$$n = \frac{2\,504}{1 + 2\,504 \cdot 0.05^2} = 345 \qquad (1)$$

The data were obtained through an on - line research questionnaire. The questionnaire survey was conducted during the years 2020-2022 through the platform docs.google.form. The questionnaire that have been researched, we can say that a survey sample of enterprises is relevant, has sufficient denunciation, which is also verified by selected mathematical and statistical methods.

H1: Enterprises of the wood processing industry that use a wider scale of quality management principles and tools (PTQM) will have a higher potential for adaptation to unexpected changes in times of crisis measured through a decrease in sales.

Figure 1 shows the relationship between the use of principles and tools of quality management in enterprises of the wood processing industry in Slovakia and the decrease in sales. As can be seen from the figure 1, companies that use a wider scale of these principles and tools show a much smaller decrease in sales compared to companies that use them to a lesser extent.

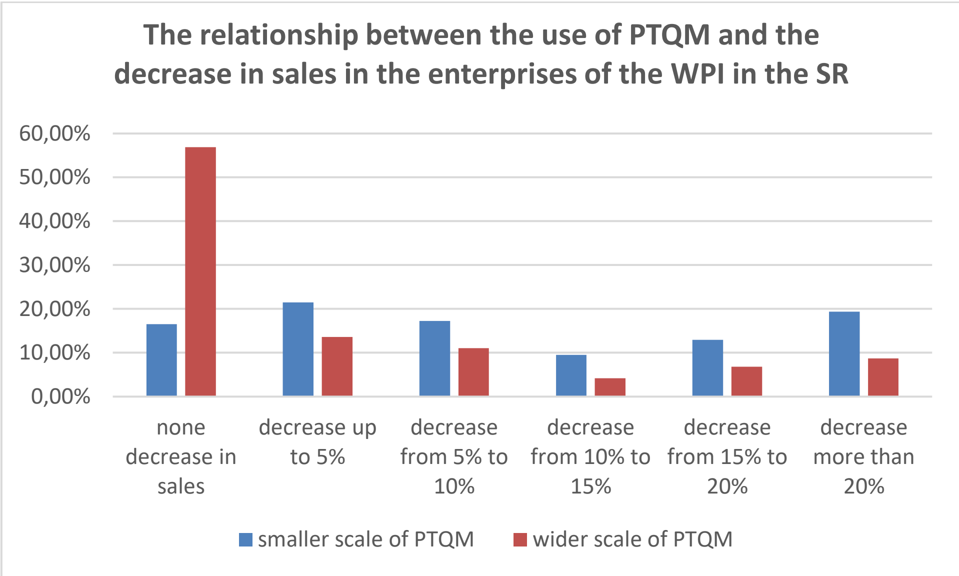

Figure 1. The relationship between the use of PTQM and the decrease in sales in the enterprises of the WPI in the SR

The findings from assessing the correlation between the utilization of PTQM and the decrease in sales are outlined in Table 1. A significant correlation was confirmed based on the corresponding p-value of 0.000. The contingency coefficient value of 0.38 indicates a moderate level of dependency.

Table 1. A sample of the table

Usage of PTQM versus Decrease in Sales	Chi-square test	Degree of freedom	p-level	Contingency coefficient
	59.89	5	**0.000**	0.38

4. CONCLUSION

The article examines the implementation of quality management systems within the wood processing industry enterprises in Slovakia. Its primary objective was to validate the hypothesis suggesting that companies in this sector employing a broader array of quality management principles and tools exhibit greater resilience to unforeseen impacts, as evidenced by a decrease in sales during crises. The findings of the study confirm this hypothesis, thus supporting the theoretical proposition regarding the favourable impact of quality management systems on business performance and economic outcomes. However, it is noted that opportunities for improvement still exist, particularly among micro and small enterprises where the implementation of quality management systems remains limited. Various factors contribute to this situation, including a shortage of skilled labour, scepticism regarding the beneficial effects of quality management systems on company economics, existential challenges faced by businesses, among others.

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REFERENCES

1. Albuhisi, A. M., and Abdallah, A. B., 2018. The impact of soft TQM on financial performance: The mediating roles of non-financial BSC perspectives. *International Journal of Quality & Reliability Management*, 35 (7), 1360–1379. https://doi.org/10.1108/IJQRM-03-2017-0036
2. Alharbi, K., Yusoff, R. Y., and Al-Matari, E. M., 2017. "*The Moderating effect of organizational climate on the relationship between of total quality management (TQM) on organisational sustainability: The case of the hotel industry in Saudi Arabia*," *International Business Management* 11(2), 350-356. DOI: 10.3923/ibm.2017.350.356
3. Knop, K., 2021. *The Use of Quality Tools to Reduce Surface Defects of Painted Steel Structures*. Manufacturing Technology, 21(6), 805–817, https://doi.org/10.21062/mft.2021.088
4. Kuhn, M., Schaefer, F. and Otten, H., 2018. Process complexity as a future challenge – a quality management perspective. *The TQM Journal*, 30 (6), 701–716. https://doi.org/10.1108/TQM-10-2017-0123
5. Lind, D. A., 2020. *Statistical Techniques in Business and Economics*. McGraw-Hill. 880.
6. Nenadál, J., Plura, J., Noskievičová, D., Vykydal, D., Hofbruckerová, Z., Tošenovský, F., Klaput, P., 2018. *Management kvality pro 21. století*. Management Press, 368, ISBN 978-89-7261-561-2.
7. Nguyen, M. H, Phan, A. Ch., and Matsui, Y., 2018. "*Contribution of quality management practices to sustainability performance of Vietnamese firms*," Sustainability 10*(2*), 375. DOI: 10.3390/su10020375
8. Rebelo, M. F., Santos, G., and Silva, R., 2016. "*Integration of management systems: towards a sustained success and development of organizations*," Journal of Cleaner Production 127, 96-111. DOI: 10.1016/j.clepro.2016.04.011Mirski, R.; Majka, J.; Dziurka, D. (2012): *The Effect of Residual Swelling after Drying on Internal Bond in OSB*. Drvna Industrija 63 (4): pp. 241-247
9. Sarb, A., Glevitzky, I., Itul, L., Popa, M., 2019. *The improvement of quality management system in a porcelain factory*. MATEC Web of Conferences Vol. 290, Article number 05003, https://doi.org/10.1051/matecconf/201929005003
10. Siltori, P. F. S., Rampasso, I. S., Martins, V. W. B., Anholon, R., Silva, D., and Pinto, J. S., 2020. Analysis of ISO 9001 certification benefits in Brazilian companies. *Total quality management & business excellence,* 32 (13–14), 1614–1632. https://doi.org/10.1080/14783363.2020.1756246
11. Su, H. C., Kao, T. W., Linderman, K., 2020. Where in the supply chain network does ISO 9001 improve firm productivity? *European journal of operational research*, 283 (2), 530–540. https://doi.org/10.1016/j.ejor.2019.11.042

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DIGITALIZATION IN WOOD AND FURNITURE COMPANIES

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Abstract: Due to rapid technological development and increasing digitalization, the business environment, also in the wood sector, is changing rapidly. The unique aspects of this sector, including the variability of raw materials, the nuances of production processes and fluctuating market dynamics, require customized digital solutions. This study, based on existing strategies, reports and literature, describes the current state of digitalization and the use of Industry 4.0 tools in the Slovenian wood and furniture industry. It also highlights some of the opportunities and challenges that the industry might face in digital transformation. Our findings show that the adoption of digital technologies is relatively low and that the size of a company strongly influences the degree of digitalization. The sector is dominated by smaller companies, which often have limited resources and may prioritize immediate operational needs over long-term strategic investments such as digitalization. Another major hurdle to digital transformation in wood and furniture companies, which have a relatively low-skilled workforce is human capital. Therefore, the success of the sector's digitalization will depend on a coherent government strategy and support for the adoption of digital technologies. Companies need to take a long-term approach, develop a tailored strategy that considers their unique context and capabilities, and focus not only on structures and processes, but also on people.
Keywords: digitalization, industry 4.0, manufacturing companies, wood and furniture companies

1. INTRODUCTION

In the digital age, transformative changes are sweeping across industries, and the wood sector is no exception. Today, companies are facing critical decisions regarding their investments in new technologies and the strategic allocation of resources to stay competitive. In the context of the fourth industrial revolution (Industry 4.0), several technological pillars and trends are driving digital transformation. These include blockchain, digital twins, quantum computing, advanced analytics and artificial intelligence (Panetta, 2018). As organizations navigate this landscape, they must determine how to effectively utilize these innovations.

A central concept is the emergence of the “smart factory”, also known as the U-factory, factory of things or smart factory of the future (Hozdić, 2015; Movrin, 2017). The smart factory integrates human expertise, product design, manufacturing processes and organizational structures into a cohesive system. Its components include smart products, smart equipment, smart people, smart conceptual processes and smart management. Industry 4.0 centers on smart factories, where the creation of intelligent products and sustainable processes is paramount (Červený et al., 2022). Globalization and networking will be decisive for the future nature of production also in the post Industry 4.0 era (Matt & Rauch, 2020). However, a new paradigm is emerging: Industry 5.0. In contrast to its predecessors, Industry 5.0 prioritizes people, placing them at the forefront of cyber-physical systems (CPS). This model promotes the symbiosis between humans and technology and recognizes that innovation should enhance human capabilities rather than replace them. The term Human-Cyber-Physical System (HCPS) sums up this vision (Saniuk et al., 2022). Industry 5.0 emphasizes the fusion of artificial intelligence with everyday human experiences, empowering the individuals and repositioning them as a central actors in the technological universe. In this context, the more appropriate term could be Society 5.0 (Červený et al., 2022; Saniuk et al., 2022). The evolution from Industry 4.0 to Industry 5.0 reflects a profound change — from purely technological advances to a harmonious coexistence of humans and machines, where innovation serves humanity's well-being.

This study, based on existing strategies, reports and literature, describes the current state of digitalization and the use of Industry 4.0 tools in the Slovenian wood and furniture industry. It also highlights some of the opportunities and challenges that the industry might face in digital transformation.

2. STATE OF DIGITAL ECONOMY IN SLOVENIA

National statistics shows that in Slovenia in 2023 most companies (48%) had a very low digital index, 29% of companies had a low index, 18% had a high index and 5% of companies had a very high digital index (Figure 1). Among small legal entities, the majority had a very low digital index (54%), among medium-sized legal entities a low index (35%) and among large legal entities a high digital index (43%) (SURS, 2023a). The goal of the European Digital Decade (EC & CNECT, 2023), also in Slovenia, is for more than 90% of SMEs to reach at least a basic level of digital maturity by 2030, i.e. a low, high or very high digital index. This is particular challenging for companies in the manufacturing sector, where the digital index is even lower, as 62% of manufacturing companies had a very low digital index. Two thirds of companies faced digital transformation challenges, with 41% due to a lack of suitable staff or knowledge: 40% small, 46% medium and 54% large companies (SURS, 2023a).

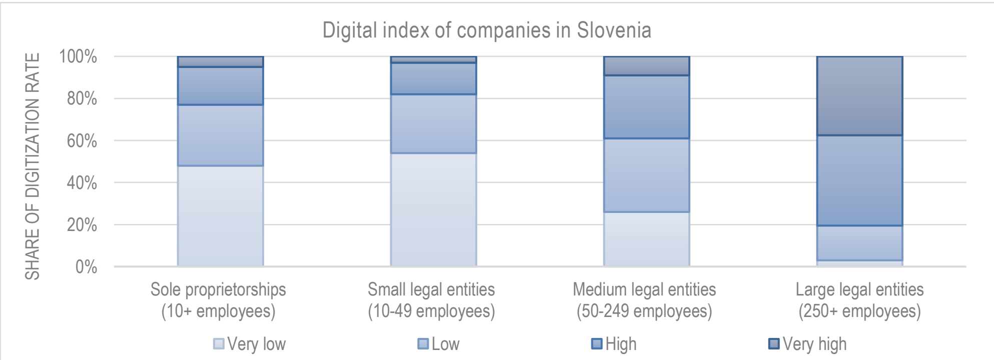


Figure 15. Digital index of companies in Slovenia (SURS, 2023a)

This is in line with the Digital Economy and Society Index (DESI) report (EC, 2022), in which Slovenia ranks below the EU average in the dimension of human capital (Figure 2). However, Slovenia is already addressing this issue, as competences and digital inclusion are one of the pillars of the Digital Slovenia 2030 strategy (Ministry of Digital Transformation, 2023). The country has also launched a national curriculum reform for all levels of formal education and is focusing on upskilling and reskilling working and non-working adults, pensioners, and people with disabilities.

According to the DESI report, Slovenia is above the EU average when it comes to integrating digital technologies into business activities. Basic digital intensity of SMEs is in line with the EU average, but they are above average in e-invoicing, use of ICT for environmental sustainability and e-commerce. Electronic information exchange has increased to 36% but is still below the EU average. More companies are using social media and cloud services, but the use of big data is still behind the EU average (EC, 2022).

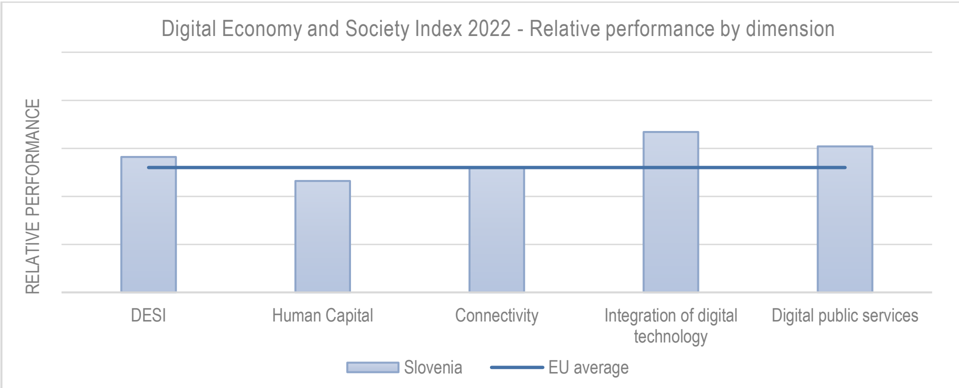
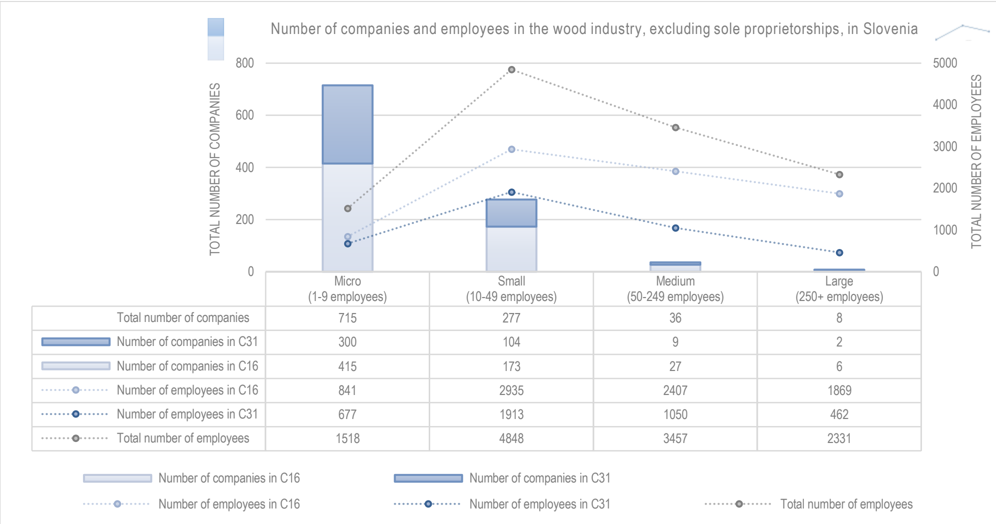


Figure 216. Relative performance of DESI in Slovenia (EC, 2022)

Nevertheless, according to Statistical Office of RS (SURS, 2023a), companies are still struggling with a lack of financial resources, management of operations are unable to adapt quickly to changes in the environment and half of companies believe that digital transformation is not necessary for successful business operations. The state is also responding to these challenges as it is increasingly prioritizing the digital transformation of its economy and public sector, which is reflected in its legal and regulatory framework and the Recovery and Resilience Plan (RRP) (RS, 2021). The Digital Slovenia 2030 strategy (Ministry of Digital Transformation, 2023) will provide the overarching framework for digital transformation and integrate all sectoral strategies. The Strategy for the Digital Transformation of the Economy 2021-2030 (Ministry of the Economy, Tourism and Sport, 2022), adopted in January 2022, is also one of the reforms of RRP. It focuses on advanced technologies such as artificial intelligence, the internet of things, big data, blockchain, high-performance computing, quantum computing and 5G to drive economic growth and competitiveness. Several measures have been taken to encourage companies to adopt these advanced digital solutions. The Corporate Income Tax Act now includes tax relief for investments in digital transformation, including cloud computing, AI, and big data. The RRP also provides grants for investment in the digital transformation of industries and businesses, targeting both large companies and SMEs. The Chamber of Commerce and Industry leads the Ai4si initiative, which supports the implementation of big data and AI in companies. The Slovenian Enterprise Fund offers digital vouchers of up to 10 000 € to over 4 300 SMEs to prepare their digital strategy, improve their digital skills and increase cybersecurity. It also provides grants of 100 000 € for the digital transformation of up to 480 SMEs. SPIRIT Slovenia, a public agency, offers grants of up to 30 000 € for SMEs using digital tools to operate internationally (EC, 2022).

2.2. Wood and Furniture Industry in Slovenia

Based on the business indicators for 2022 of the Chamber of Commerce and Industry in Slovenia (GZS, 2023), the wood processing sector (C16 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials), comprises a total of 621 legal entities excluding sole proprietorships (Figure 3). This includes 415 (66.83%) micro companies, 173 (27.85%) small companies, 27 (4.34%) medium-sized companies and 6 (0.97%) large companies. Together, these companies employ a total of 8 052 people.



	Micro (1-9 employees)	Small (10-49 employees)	Medium (50-249 employees)	Large (250+ employees)
Total number of companies	715	277	36	8
Number of companies in C31	300	104	9	2
Number of companies in C16	415	173	27	6
Number of employees in C16	841	2935	2407	1869
Number of employees in C31	677	1913	1050	462
Total number of employees	1518	4848	3457	2331

Figure 3. Number of companies and employees in the wood and furniture industry, excluding sole proprietorships, in Slovenia (GZS, 2023)

The furniture manufacturing sector (C31 - Manufacture of furniture), consists of a total of 415 legal entities excluding sole proprietorships. This includes 300 (72.29%) micro companies, 104 (25.06%) small companies, 9 (2.17%) medium companies and 2 (0.48%) large companies. These companies employ a total of 4 102 people. Legal entities excluding sole proprietorships in these two sectors together employ about 1.24% of the total working population in Slovenia, which corresponds to 982 000 people in 2022 (SURS, 2023b).

3. DISCUSSION AND CONCLUSIONS

The data shows that the level of digitalization in wood and furniture companies in Slovenia (Kropivšek & Grošelj, 2020) follows the general index of the digital economy in Slovenia. This means that digital adoption is relatively low and that the size of a company strongly influences the degree of digitalization and related company plans for the near future. The integration of Industry 4.0 into the business is complex and requires long-term strategic investments that are more suitable for larger companies. Nevertheless, even simple, perhaps self-explanatory digital tools and solutions can have a big impact. As the sector is dominated by smaller companies, the low level of digital adoption is understandable. Smaller companies often have limited resources and may prioritize immediate operational needs over long-term strategic investments such as digitalization. Another major hurdle to digital transformation is human capital, which is even more pronounced in manufacturing companies, which have a relatively low-skilled workforce. Therefore, the success of the sector's digitalization will depend on a coherent government strategy and support for the adoption of digital technologies. Slovenia is tackling the digital divide with a comprehensive strategy that includes legislative reform, financial incentives and educational reform. The country is trying to create an environment that favors all sizes of companies.

Woodworking processes can benefit significantly from Industry 4.0 (and 5.0) as advances in robust sensors, computing power, communication infrastructure and smart algorithms now enable effective control over the variability of wood. Real-time actions can be taken based on the insights gained from the data (Ramos-Maldonado et al., 2021). In the context of investments in information and communication technology, companies in the wood and furniture sector can prioritize several areas: investing in cloud-based solutions that enable scalability, flexibility and efficient use of resources; developing smart applications and conversational interfaces that improve communication and user experience as well as offer personalized products; focusing on the development of apps and smart things that enable the integration of smart devices to optimize processes; recognizing the value of advanced materials, sensor technologies, smart control systems and smart mechatronic tools, etc. In doing so, they should focus on the importance of data as a foundation to create value for customers and gather their feedback to understand how people use their wood products optimally and to ensure proper maintenance.

The diversity within the wood sector, characterized by companies producing a wide range of products from different materials, targeting different markets and operating with different levels of digital maturity and resources, makes it difficult to develop a one-size-fits-all strategy. Companies should be aware that a successful digital transformation takes time and take a long-term approach by developing a strategy that encompasses structures, people and processes and appointing a leader who understands the big picture and leads the transformation (DITRAMA, 2022). Companies that want to transform to Industry 4.0 to become more sustainable, innovative and competitive must first assess their own digital maturity level to understand which strengths they can already leverage and which business processes they want or need to digitize.

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REFERENCES

1. Červený, L., Sloup, R., Červená, T., Riedl, M., Palátová, P. (2022): *Industry 4.0 as an Opportunity and Challenge for the Furniture Industry—A Case Study*. Sustain. 14.
2. Hozdić, E. (2015): *Smart factory for industry 4.0: a review*. Int. J. Mod. Manuf. Technol. VII, 2067–3604.

3. Kropivšek, J., Grošelj, P. (2020): *Digital Development of Slovenian Wood Industry*. Drv. Ind. 71, 139–148.
4. Matt, D.T., Rauch, E. (2020): *SME 4.0: The role of small-and medium-sized enterprises in the digital transformation*. Ind. 4.0 SMEs Challenges, Oppor. Requir. 3–36.
5. Movrin, P. (2017): *Pametna tovarna na ključ za globalni trg*. Glas Gospod. 2017.
6. Ramos-Maldonado, M., Aguilera-Carrasco, C., Ramos-Maldonado, M., Aguilera-Carrasco, C. (2021): *Trends and Opportunities of Industry 4.0 in Wood Manufacturing Processes*. Eng. Wood Prod. Constr.
7. Saniuk, S., Grabowska, S., Straka, M. (2022): *Identification of Social and Economic Expectations: Contextual Reasons for the Transformation Process of Industry 4.0 into the Industry 5.0 Concept*. Sustain. 14.
8. *** DITRAMA (2022): *Guide for the Digital Transformation Manager for the Furniture Sector.* URL: https://ditrama.eu/en/downloads
9. *** EC. (2022): *Slovenia in the Digital Economy and Society Index*.
10. *** EC., CNECT. (2023): *2030 Digital Decade: report on the state of the Digital Decade 2023*. Publications Office of the European Union.
11. *** GZS. (2023): *Business indicators. KAPOS GZS*.
12. *** Ministry of the Economy, Tourism and Sport (2022): *Strategy of Digital Transformation of the Economy*. URL: https://www.gov.si/assets/ministrstva/MGTS/Dokumenti/DIPT/Strategija-digitalne-transformacije-gospodarstva
13. *** Ministry of Digital Transformation (2023): *Digital Slovenia 2030 Strategy*. URL: https://nio.gov.si/nio/asset/strategija+digitalna+slovenija+2030?lang=en
14. *** Panetta, K. (2018): *Gartner Top 10 Strategic Technology Trends For 2019.* URL: https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2019
15. *** SURS (2023a): *Digital entrepreneurship report*. URL: https://www.stat.si/StatWeb/en/News/Index/11516
16. *** SURS (2023b): *Labour force results*. URL: https://www.stat.si/StatWeb/en/News/Index/12705
17. *** RS. (2021): *The recovery and Resilience Plan*. URL: https://www.gov.si/en/registries/projects/the-recovery-and-resilience-plan/

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SUSTAINABLE BUSINESS DEVELOPMENT AND ECOLOGICAL INNOVATION

Anna Šatanová

Abstract: The aim of the presented paper is to point out the connection between the sustainable development of the forestry company and ecological innovations, and at the same time to present ecological innovations as an important determinant of the sustainable development of the company. Every such business that wants to be environmentally friendly and prosper must implement innovations that allow finding new ways of solving environmental problems by reducing the consumption of energy resources and supporting sustainable economic activities. Next, the article deals with the analysis of ecological innovations in the activities of small and medium-sized forestry enterprises in the Slovak Republic. The strategic documents of all major international communities pay attention to the issue of ecological innovations, which represent an important tool in the process of protecting the environment and fulfilling the goals of sustainable development. In the same way, individual countries (including the Slovak Republic) integrate the agenda related to the protection and development of the environment and the support of ecological innovations into the main strategic goals of their development. That is why we also focus on the future of the development of ecological innovations in the context of ensuring sustainable development in the Slovak Republic. Achieving a climate-neutral, resource-efficient and digital economy requires the full mobilization of small and medium-sized enterprises. This fact is also pointed out by the Strategy for small and medium-sized enterprises for a sustainable and digital Europe, the aim of which is to increase the number of small and medium-sized enterprises that engage in sustainable business activities.

Keywords: forestry, enterprise, ecology, innovation, strategy, sustainable development, environment,

INTRODUCTION

Currently, the world is faced with the need to solve serious environmental issues and, together with them, major social and economic challenges, including mainly problems such as poverty, global economic inequalities and, more recently, threats arising from the global coronavirus pandemic. As a result of them, the business environment is increasingly characterized by constant and often even turbulent changes. Business entities trying to maintain or strengthen their market position must necessarily respond appropriately and flexibly to rapidly changing conditions, while they should perceive this nature of the environment as a challenge bringing new opportunities on the way to their long-term stability and competitiveness. The term sustainable development began to be used more intensively, especially after the World Commission on Environment and Development published a report in 1987 known as Our Common Future. The report defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The goal of sustainable development is to ensure long-term stable economic growth and environmental protection, which can only be achieved through the integration of appropriate economic, environmental and social aspects in the decision-making process. The current global framework of sustainable development is mainly represented by the UN program "Agenda 2030 for sustainable development". It is the most complex document containing the priorities of long-term sustainable development on a global scale, which should serve as a guide in the creation of structural, economic and social policy in individual countries. Sustainable development is an imperative today. At the company level, this is a long-term trend and for its managers it should be an important factor in shaping the vision and long-term strategy of achieving competitiveness.

1. SUSTAINABLE BUSINESS DEVELOPMENT AND ECOLOGICAL INNOVATION

Páleník et al. (2015) argue that growth in which the majority of the population participates is a means of achieving sustainable and therefore stable and persistent growth. The commitment to ensure sustainable growth and to leave no one behind ("to leave no-one behind") is also declared in the UN General Assembly resolution adopted in 2015 under the name Agenda 2030 (Transforming our world: the 2030 Agenda for sustainable development, 2015). Even Egelston (2013) perceives sustainable development as a holistic approach to the relationship between man and the environment. The term sustainable development began to be used more intensively after the World Commission on Environment and Development (WCED) published the Brundtland Report in 1987, also known as Our Common Future. The report defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Marková, Lesníková, Kaščáková and Vinczeová (2017) define the concept of sustainable business development as a comprehensive approach leading to the harmonization of economic growth, environmental and social issues in the long term, which is focused on the strategy and performance of the business. Porter and Kramer (2011) claim that the implementation of sustainable development policy in companies increases their competitiveness and at the same time contributes to the improvement of economic and social conditions in the communities where such companies operate. ISO standard 14001 specifying the requirements for the environmental management system in organizations was one of the significant manifestations of the effort to actively minimize negative impacts on the environment. By 2020, this standard was implemented in almost 350,000 organizations in 195 countries of the world. Currently, we see that companies in developed as well as in developing countries are increasingly taking sustainability aspects into account in their business activities (Bojnec, Tomšič, 2021).

The creation and introduction of ecological innovations is linked to the need to ensure the sustainability of economic activities. Ecological innovations lead to the reduction of the impact of economic activities on the environment and the rational and sustainable use of natural resources, and therefore can be considered an important factor in solving problems related to natural resources, energy security and climate change. Regarding the economic dimension of the sustainable development of the enterprise, the goal of ecological innovations is to reduce energy and material costs, to increase the competitiveness of the enterprise, its productivity and profitability through the rational consumption of resources and through access to products, technologies and markets that are more environmentally friendly.

According to O'Hare et al. (2014) ecological innovation refers to the development and application of a business model that is shaped by a new business strategy that includes sustainability in all business operations based on the life cycle in cooperation with partners in the entire value chain. In Japan, eco-innovation is at the core of Japan's Strategy for a Sustainable Society in the 21st Century (OECD, 2008c).

2. ECOLOGICAL INNOVATIONS IN THE ACTIVITIES OF SMALL AND MEDIUM-SIZED ENTERPRISES IN THE SR

As a member country of the European Union, Slovakia is interested in implementing the main objectives of the EU's environmental strategies into national policies. In Slovakia, the issue of environmental protection and ecological innovations is elaborated in strategic documents of several departments of the state administration. The dominant role in the process of transforming the economy into a green economy is held by the Ministry of the Environment of the Slovak Republic, but the area of ecological innovations also affects the Ministry of the Economy of the Slovak Republic, the Ministry of Agriculture and Regional Development of the Slovak Republic, the Ministry of Education, Science, Research and Sports of the Slovak Republic and the Ministry of Transport.

According to the results of the Eco-Innovation Scoreboard, in 2019, Slovakia achieved a total value of the eco-innovation index of 62, placing it in 23rd place among the 28 EU member states. A score of 62 means that Slovakia's overall eco-innovation performance is 38% below the average level of EU member states. The calculated value of the eco-innovation index expresses by how many % the value of the indicator is lower (higher) compared to the EU average, which represents a value of 100%. When determining them, the OECD "Distance-to-Reference" methodology is used (Eco-Innovation Observatory, 2018b). Eco-innovation inputs and eco-innovation outputs appear as the weakest components of the aggregated eco-innovation index in Slovakia. This is mainly due to the low share of public spending on science and research directed to the environment and energy. In 2019, eco-innovation inputs represented only 26% of the average of EU countries. We can positively evaluate the fact that Slovakia exceeds the vast majority of EU countries in the number of companies that have implemented an environmental management system (ISO 14001) (proportion of Slovakia: EU average = 2.45). This indicator contributed positively to the overall value of the Eco-innovation activities component.

An important group of subjects influencing Slovakia's eco-innovation performance is represented by small and medium-sized enterprises, where we also include forestry enterprises, which play an important role in the country's economy. According to data from the Slovak Business Agency (2020), small and medium-sized enterprises in Slovakia make up 99.8% of the total number of business entities, provide job opportunities for almost 72.7% of the active workforce and participate in 55% of gross production and creation of added values. Their involvement in eco-innovation activity significantly affects the overall eco-innovation performance of the country.

The results of the survey show that small and medium-sized enterprises of the Slovak Republic, which implemented at least one of the mentioned eco-innovation activities, financed their implementation mainly from their own funds. Evaluating the involvement of small and medium-sized enterprises in eco-innovation activities requires identifying the main motives and barriers determining their eco-innovation activities.

Table 1 Share of small and medium-sized enterprises implementing eco-innovation activities (%)

eco-innovation activities of the EU SR	**EU**	**SR**
Waste minimization	65	44
Energy saving	63	58
material saving	57	43
Water conservation	47	45
recycling and reuse of material or waste in the enterprise	42	35
Proposal of a new product design that is easier to maintain, repair or reuse	25	14
Use of renewable energy sources	14	5

Source: Processing based on data from Euroflash Barometer 456 - EU, 2018

The first comprehensive survey on the motives of eco-innovation activity of small and medium-sized enterprises was conducted in EU member countries in 2011.
The results of the questionnaire survey showed that small and medium-sized enterprises stimulate the introduction of eco-innovations within their business activities in particular:
- high energy prices,
- expected/anticipated future growth in the price of energy,
- good business partners (in this context, we see a connection between the motives of eco-innovation activity and the entities with which companies cooperate in the implementation of eco-innovations).

Barriers, or obstacles, are factors that negatively affect the eco-innovation efforts of companies. The following table shows the result of the survey in this area.

The overall results of the survey confirm the importance of professional knowledge necessary for the implementation of eco-innovation activities.

In a separate question, the companies indicated the forms of aid they consider important from the point of view of supporting eco-innovation activities (table 3).

Tabl. 2 Share of smalland medium-sized enterprises that identified the mentioned barriers as key for the implementaation of eco-innovation activities (%)

Barriers to eco-innovation activities	EU	SR
Difficulty of administrative and legal procedures	33	30
Cost of eco-innovationactivities	24	12
Difficulty of implementing environmental legislation in the company	22	14
Lack of professional environmental expertise	20	8
Difficulty of technical requirements for implementation	20	8
Insufficient demand for eco-innovation products and services	17	9
Insufficient supply of required materials	14	8

Source: Processing based on data from Euroflash Barometer 456 - EU, 2018.

The overall results of the survey confirm the importance of professional knowledge necessary for the implementation of eco-innovation activities.

In a separate question, the companies indicated the forms of aid they consider important from the point of view of supporting eco-innovation activities (table 3).

Tabl 3 Share of small and medium-sized enterprises that identified the mentioned forms of aid as the most important (%)

	EU	SR
Grants and financial support	36	28
Consultation on how to improve eco-innovation activity in the company	23	17
Explanation of new technologies and processes	22	16
Advice on finding options and financial planned eco-activities	22	10
Cooperation between enterprises within the sector	20	14
Database of case studies on eco-innovation activities	15	10

Source: Processing based on data from Euroflash Barometer 456 - EU, 2018.

It can be concluded that small and medium-sized enterprises in the Slovak Republic, including forestry enterprises, encounter several barriers to eco-innovation. Identification of barriers to eco-innovation activity is the first step and prerequisite for overcoming them.

We can also say that Slovakia has significant reserves in the implementation of eco-innovations in business practice. Compared to the average of EU countries, small and medium-sized enterprises of the Slovak Republic show a lower involvement in eco-innovation activities. To increase the involvement of small and medium-sized enterprises in eco-innovation activity requires, on the one hand, to increase the involvement of small and medium-sized enterprises themselves, on the other hand, an important factor that determines the eco-innovation activity of small and medium-sized enterprises is the policy of supporting eco-innovations.

3. CONCLUSION

Small and medium-sized enterprises and forestry play a key role in ensuring sustainable development, which would not be possible without their involvement. The policy of sustainable development focuses on eco-innovations in many areas. Eco-innovations reduce material requirements, use closed material flows, or create use of new materials. At the same time, they focus on reducing energy requirements, create or they use alternative sources of energy, reduce total emissions into the environment or existing environmental burdens and health risks while generally supporting the idea of a healthy lifestyle and sustainable development. The positive effects of ecological innovations are manifested in all aspects of the sustainable development of the company

REFERENCES

1. Bojnec, Š., Tomšič, N.,(2021). *Corporate sustainability and enterprise performance The mediating effects of internationalization and networks*. In: International Journal of Productivity and Performance Management [online], zv. 70, č. 1, s. 21 – 39. ISSN 1741- 0401.
2. Brundtland, G. H.,(1991). *Our common future*. In: Tolba, M. K., Biswas, A. K. Earth and Us. Population-Resources-Environment-Development. Oxford: Butterworth Heinemann Ltd., 1991. ISBN 0-7506-1049-2.
3. Egelston, A. E., (2013). *Sustainable Development. A History [online].* Dordrecht: Springer Science+Business Media, 2013. ISBN 978-94-007-4877-4. Dostupné na internete: https://rd.springer.com/book/10.1007/978-94-007-4878-1
4. ISO Survey 2020. (2021) [online]. Ženeva: International Organization for Standardization, 2021. Dostupné na internete: https://www.iso.org/the-iso-survey.html
5. Lesáková L. a kol. (2021). *Ekologické inovácie a udržateľný rozvoj v malých a stredných podnikoch SR,* Vydavateľstvo Belianum, UMB , Banská Bystrica, 162 s., ISBN 978- 80-557-1930-6.
6. Marková, V., Lesníková, P., Kaščáková, A., Vinczeová, M., (2017). *The present status of sustainability concept implementation by businesses in selected industries in the Slovak Republic*. In: E+M – Ekonomie a Management, zv. XX, č. 3/2017, s. 101 – 116. ISSN 1212-3609.
7. O'hare, J. A., McAloone, T. C., Pigosso, D. C. A., Howard, T. J., (2014). *EcoInnovation Manual: Working version for Pilot Application. United Nations Environment Programme [online].* [cit. 2018-11-03]. Dostupné na internete: http://orbit.dtu.dk /files/103602469/Eco_ Innovation_Manual.pdf
8. OECD, (2008c). *Eco-Innovation Policies in Japan [online*]. [cit. 2018-11-03]. Dostupné na internete: https://www.oecd.org/japan/42876953.pdf
9. OECD, (2018). *Towards green growth [online].* [cit. 2020-07-11]. Dostupné na internete: https://www.oecd.org/greengrowth/48012345.pdf
10. Páleník, V. a kol., (2015). *Inkluzívny rast v stratégii Európa 2020 – naivita alebo genialita?* Bratislava: Ekonomický ústav Slovenskej akadémie vied, 2015. 345 s. ISBN 978-80-7144-251-6.
11. Porter, M., Kramer, M., (2006). *Strategy and society: the link between competitive advantage and corporate social responsibility*. In: Harvard Business Review, č. 84, s. 78– 92.
12. SLOVAK BUSINESS AGENCY, (2020a). Report on the State of Small and Medium-sized Enterprises in the Slovak Republic. Bratislava: Slovak Business Agency. [online]. [cit. 2020-07-11]. Dostupné na internete: http://www.sbagency.sk/en/state-of-small-andmedium-entreprises
13. SLOVAK BUSINESS AGENCY, (2020b). *Monitoring podnikateľského prostredia* [online]. Bratislava: Slovak Business Agency. [cit. 2020-07-11]. Dostupné na internete: https.//monitoringmsp.sk/2020/04/30/kvalita-podnikateskeho-prostredia/
14. *Transforming our world: the 2030 Agenda for Sustainable Development [online].* (2015). New York: United Nations, 2015. Dostupné na internete: https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

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SUSTAINABLE MANAGEMENT OF FOREST-BASED RECREATION IN BULGARIA

Petya Ivanova

Abstract: The integration of the concept of sustainable development into different spheres of economy and public life has engaged professionals in recent decades. Recreation in the forest areas has an aesthetic, therapeutic and prophylactic function, and these characteristics make it particularly relevant given the increased demand for healthy tourism products. Green spaces have become one of the few sources of sustainability during the coronavirus crisis due to their restorative impact on the psychophysical health and well-being of the community. In this present environment, in addition to improving the health status of visitors, the sustainable management of forest-based recreation has the potential to contribute to rural development. Consideration of demand patterns and an adequate supply of forest-based recreation improves the quality of forest-based recreation planning, site design and visitor satisfaction.
This paper contributes to the development of frameworks and tools to support the sustainable management of tourism in forest environment as a socio-ecological complex adaptive system with multidimensional and interdisciplinary influences.

Keywords: sustainable development, forest area, recreation,

1. INTRODUCTION

Forests have always been a place where people satisfy their need for contact with nature, and the coronavirus pandemic has enhanced the importance of forests as a place for recreation. The growing trend for nature tourism and nature-based health-enhancing services, provided that environmental capacity and relevant legislation are respected, represents an opportunity to accelerate the green transition of the tourism sector (European Commission, 2024). In addition, sustainable management of recreation in forest environments provides significant opportunities for rural income and for improving the well-being of local populations, while promoting biodiversity conservation and carbon reserves storage[2].

The development of sustainable tourism models has been widely discussed in the economic literature. The demand for nature tourism has grown in recent years and there is a need for adequate planning and management tools, including innovative projects. (Filipova & Yuleva-Chuchulayna, 2020)**.**

The challenges of managing sustainable tourism are compounded when it involves development opportunities that require local community support and the management of natural resources that are usually public goods. This necessitates an analysis of the links between sustainable tourism models and forest landscape management. Proper management of public goods can lead, on the one hand, to satisfying demand and, on the other hand, to creating opportunities for sustainable development of the environment.

[2] One of the 17 Sustainable Development Goals formulated by the United Nations is to conserve life on land. Goal №15 is "Life on Land", Indicator 15.1.2 is "Sustainable forest management".One of the ways to achieve this goal is to exploit the tourism potential.

2. MATERIALS AND METHODS

The method used is of document research on existing and accessible sources of information such as: planning and strategic documents, statistical sources, normative documents and scientific publications. On the basis of content analysis, essential characteristics of the sustainable management of recreation in a forest environment are derived. The survey method is used to identify the preferred ways of recreation. The results of the studies are systematized in a SWOT analysis of forest-based recreational tourism in Bulgaria. The generalizations and analyses are carried out using general scientific methods such as analysis and synthesis, induction and deduction, etc.

3. DISCUSSION AND ANALYSES

3.1. Forest-based recreation (FBR) – dimensions

Modern tourism demand. The author's empirical research on changes in recreation preferences after the lifting of restrictions from the coronavirus pandemic shows an increased desire of people to spend time outdoors (56% increase hours outdoors, 38% have no change and only 6% register decrease). The strongest increase is in the following activities: enjoying nature (73%) and hiking (71%). The respondents' answer to the question about the changed behaviour after the pandemic, is: there is an increased assessment of the health benefits of recreation – 32.4%; appreciation of the importance of nature and respect for its protection increase – 48.5%; people avoid crowded places – 51.5%. The data strongly indicate that the demand for recreation in a forest environment is a topical modern trend. Recreation through forest ecosystems is part of the recreation through natural resources and it has both environmental and health dimensions.

Health benefits. In addition to providing fresh air, clean water and other ecological environment conducive to human health, forests can also secrete various plant essences, also known as phentermine, which have various physiotherapeutic properties such as antitumor, lowering blood pressure, relieving pain and improving human immune function (Yau & Loke, 2020). Scientific research has identified a number of health benefits that can be derived from recreational activities in the forest for visitors. These benefits include improving physical and mental health by stimulating brain activity and autonomic activity, alleviating anxiety and stress, and recovering from attention fatigue (Song, Ikei, & Miyazaki, 2019). Forest-based recreation also enhances creativity, improves sleep quality and strengthens memory (Schuh & Immich, 2022), (Huang, 2022).

The health benefits of *different forest types* vary greatly depending on the tree species, their height, density and age. Coniferous and deciduous mixed forests are considered the most suitable species for forest-based recreation and remedial activities, followed by subtropical broad-leaved evergreen forests. Forests with high numbers of dead or senescent trees are not suitable for FBR because these trees have reduced or lost photosynthesis, resistance to pathogens, and the ability to provide oxygen, phytoessence, and negative oxygen ions

(Tomalak, Rossi, Ferrini, & Moro, 2010).The quality of the forest ecological environment is related to valuable landscape (scenery, seasonality).

On the one hand recreational effects depend on the forest ecological environment and, on the other hand – on the behaviour of the visitors and the qualifications of the guides. As a model of eco/rural tourism, *guides* play a key role in tourist satisfaction. Their professional qualities make a significant contribution to the effectiveness of the FBR. Also, the quality work of guides is decisive for the behaviour of tourists, as they play a guiding and protective role in preventing conflicts and reducing the likelihood of possible risks.

Risks for tourists. They can be caused by the environment: infectious diseases from insect bites, injuries from animals, harmful plants, natural disasters. Safety challenges caused by tourists are related to careless behaviour, unsanitary eating environment, poor equipment, presence of allergies, accidental injuries.

Risks for ecosystems: climate change and anthropogenic damage. Climate change can lead to extreme natural phenomena and extreme temperatures. The frequency and intensity of these natural disasters depend on weather and climate, and an unstable climate is associated with new natural disasters that affect the landscape, biodiversity and invasive forest species. Among the anthropogenic challenges is environmental damage, including disruption of forest ecosystems, reflected in the reduction of biodiversity, loss of species, destruction of natural habitats and increased pollution from waste, sewage, noise, etc. It can lead to negative effects on the soil (erosion, damage to the habitat of living organisms, reduction of attractiveness); plants (loss of species, reduction of diversity, deterioration of quality); animals (disruption of their way of life, loss of species); gradual depletion of natural resources. Anthropogenic disturbances are widespread and difficult to control. Overcrowding of visitors, the use of means of transport, construction of infrastructure can directly or indirectly harm the forest ecosystem. People's personal hygiene habits and their attitude towards the forest are also a significant factor.

3.2. Sustainable management of recreational tourism in the forest territories of Bulgaria

Good tourism planning can prevent, in addition to the risks mentioned above, a number of negative effects related to the destruction of natural and cultural heritage, changes in the structure of the local economy, the values in the culture of the local population and the cultural landscape. Near the forest areas there are small settlements with an aging population. The local community providing tourism services – accommodation, food – needs support. A good example is Japan, where a forest therapy programme is established as a means of revitalizing remote forest communities and a business opportunity for rural areas (Ohe, Ikei, Song, & Miyazaki, 2017).

In Bulgaria, there is an established bed base for rural tourism, but it is too heterogeneous in terms of quality and accessibility. Ecotourism occupies fifth place among the types of tourism with a relative share of 4.2% (Ministry of Tourism Republic of Bulgaria, 2024). The leading factors when choosing ecotourism in Bulgaria are: beautiful nature, fresh air (54.1%); natural attractions (17.1%); diversity of plant species (15.0%); tranquility (12.7); diversity of animal species (11.8%) (Strategy for sustainable development of tourism in Bulgaria 2014-2030, 2024).

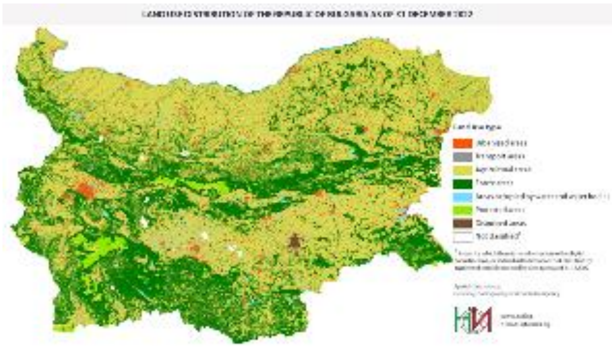

Figure 1. Land use distribution of the Republic of Bulgaria, 31/11/2022
Source: National Statistical Institute; https://www.nsi.bg

Forest territories in Bulgaria occupy an area of 37,054.27 sq km of the total territory of the country – 110,996.71 sq km according to data of the National Statistical Institute as of 31.12.2023 (National Statistical Institute, 2024). In relative terms, this represents more than a third of the country's total territory (see Fig. 1).

In terms of biological diversity, Bulgaria ranks second among the countries in Europe. There are more than 12,360 species of plants, of which 763 species are in the Red Book of Bulgaria. There are approximately 750 medicinal plants. There are 27 thousand species of invertebrate fauna, 750 species of vertebrates, of which 397 species of birds, 207 species of freshwater and Black Sea fish species, 94 species of mammals, 52 species of amphibians and reptiles.

Three national parks have been created in the country – "Pirin" (UNESCO), "Rila", "Central Balkan", as well as 11 natural parks and 89 reserves (17 have been declared biosphere according to the UNESCO programme). There are 2234 natural attractions on the territory of the country. Two of the natural sites – "Pirin National Park" and "Srebarna" reserve, are included in the UNESCO list of World Natural Heritage. Four of the reserves have been declared important wetlands under the Convention on Wetlands of International Importance. Twenty-two sites have been designated by Birdlife International as important bird habitats in Europe. In the mountains there are marked trails with a total length of over 37,000 km.

International long-distance paths pass through the territory of the country – the final section (Kom - Emine) of the E-3 European path, the E-4 European path – "Vitosha - Verila - Rila - Pirin" and the E-8 European path – "Rila - Rhodopes".

The conducted studies on the conditions and requirements for sustainable management allow us to systematize the strengths, weaknesses, opportunities and threats to the development of tourism in forest areas in Bulgaria, presented in Table 1.

Table 1. SWOT analysis of tourism in forest territories in Bulgaria

Internal environment	
Strengths	Weaknesses
• natural resources • European financial instruments • superstructure for rural tourism • demand for healthy tourism products • Bulgaria is included in the European Forest Fire informantion System (EFFIS)	• lack of a comprehensive tourism product • poor tourism infrastructure • coordination and synergy between stakeholders • marketing strategy for offering this kind of tourism • not sufficiently good strategic forest management; illegal actions (felling)
External environment	
Opportunities	Threats
• improving access to funding from European programs • sustainable use of the potential of natural resources, landscape and biological diversity for people's recreational purposes • building of infrastructure for tourism in the forest territories, taking into account the carrying capacity of the resource • information provision • tourism planning • promoting FSC certification	• climate changes • the economic situation in the country • risks of natural disasters, fires, contagions, etc. • unsustainable management of tourism in forest areas and disruption of ecosystems • poor tourism service – deteriorated age structure, professional qualification, tailored to the specifics, etc.

4. CONCLUSION

There is *a current trend* of an increased demand for recreation in nature under the influence of a number of factors. In Bulgaria *there are conditions* for offering FBR. To ensure the sustainability of forest-based tourism and maximize its benefits, it is necessary that the management exploits the strengths and opportunities and reduces the threats.

Due to the sensitivity of the forest environment to human intervention, the development of this type of tourism must take into account the limitation of the *load capacity* of the resource. Preserved forests underlie the recreational impact, and this is also an important means of dealing with climate change – a significant modern problem of sustainability. Having intelligent monitoring can provide timely information about the recreational environment which is to prevent the threats to the resource and to the health of tourists.

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REFERENCES

1. European Commission. (2024, 01 12). Retrieved from New EU Forest Strategy for 2030: https://commission.europa.eu/document/cf3294e1-8358-4c93-8de4-3e1503b95201_en
2. Filipova, M., & Yuleva-Chuchulayna, R. (2020). Innovation Projects as a Factor for Strategic Development of Small and Medium-sizes Enterprises. *Revista Inclusiones, 7*(SI), 461-476.
3. Huang, Z. (2022). Research on the Construction of Forest Health Care Trails based on the Perspective of Promoting Sports Health. *Forest Chemicals Review*, 1949-55.
4. Jaung, W. (2022). Digital forest recreation in the metaverse: Opportunities and challenges. *Technological Forecasting & Social Change, 185*. doi:https://doi.org/10.1016/j.techfore.2022.122090
5. Liu, H., Xu, X., Tam, V. V., & Mao, P. (2023). Exploring the 'dark' side of forest therapy and recreation: A critical review and future directions. *Renewable and Sustainable Energy Reviews, 183*(113480). doi:https://doi.org/10.1016/j.rser.2023.113480
6. *Ministry of Tourism Republic of Bulgaria*. (2024, 01 18). Retrieved from https://www.tourism.government.bg
7. *National Statistical Institute*. (2024, 01 20). Retrieved from https://www.nsi.bg
8. Oh, B., Lee, K. J., Zaslawski, C., Yeung, A., Rozenthal, D., Larkey, L., & Back, M. (2017). Health and well-being benefits of spending time in forests: systematic review. *Environmental Health and Preventive Medicine, 22*. doi:https://doi.org/10.1186/s12199-017-0677-9
9. Ohe, Y., Ikei, H., Song, C., & Miyazaki, Y. (2017). Evaluating the relaxation effects of emerging forest-therapy tourism:A multidisciplinary approach. *Tourism Management, 62*, 322-334. doi:https://doi.org/10.1016/j.tourman.2017.04.010
10. Schuh, A., & Immich, G. (2022). Home Forest Therapy - The Potential of the Forest for Your Health Chapter. In *Forest Therapy - The Potential of the Forest for Your Health* (pp. 61-88). Springer.
11. Song, C., Ikei, H., & Miyazaki, Y. (2019). Physiological effects of forest-related visual, olfactory, and combined stimuli on humans: An additive combined effect. *Urban Forestry & Urban Greening, 44*. doi:https://doi.org/10.1016/j.ufug.2019.126437
12. *Strategy for sustainable development of tourism in Bulgaria 2014-2030.* (2024, 01 16). Retrieved from https://www.tourism.government.bg/sites/tourism.government.bg/files/uploads/strategy-policy/strategy_2014-2030_13_05_2014-sled_ms_26_05_2014.pdf
13. Tomalak, M., Rossi, E., Ferrini, F., & Moro, P. A. (2010). Negative Aspects and Hazardous Effects of Forest Environment on Human Health. In *Forests, Trees and Human Health* (pp. 77-124). Springer.
14. Yau, K. K., & Loke, A. Y. (2020). Effects of forest bathing on pre-hypertensive and hypertensive adults: a review of the literature. *Environ Health Prev Med, 25*(23). doi:https://doi.org/10.1186/s12199-020-00856-7

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SUSTAINABLE MACROECONOMIC PERSPECTIVES AND POLICY INITIATIVES IN THE FORESTRY-BASED SECTOR

PREVENTING DEFORESTATION AND FOREST DEGRADATION VIA LEGAL MECHANISMS – CHALLENGES AND PERSPECTIVES

Mariela Deliverska

Abstract: Forestry is one of the sectors where attention is needed to ensure achievement of mitigation and adaptation targeting prevention of deforestation and forest degradation. Causes of deforestation are complex, varying across countries and often are being affected by different social, cultural, and macroeconomic conditions. Existing threats to the world's forests provide some of the major sustainability challenges of our time. Deforestation is a major cause of biodiversity decline which requires planning of complex strategic actions and providing specific measures for achieving biodiversity conservation. Planning and monitoring forest and land-use activities could not be solidly achieved by applying individual measures without taking into account the possibilities of setting, implementing and achieving targeting goals. Legal and financing mechanisms, as well as policy measures could serve as support to national, regional and international forest planning efforts, including support to reduce of risk of direct negative impacts to forests.
Keywords: regulatory framework, legal mechanisms, prevention, deforestation

Deforestation and forest degradation is a significant problem emphasizing its profound impacts on the environment, society, and economy. When facing such problem, which has potential to provide massive negative impact and could provide some of the major sustainability challenges of our time, main focus should be placed on the role of legal framework as essential instrument for prevention of deforestation and forest degradation as well as support ecological conservation.

Establishing and applying legal mechanism in the scope of preventing deforestation and forest degradation is not an easy task especially considering that causes of deforestation are complex, varying across countries and often are being affected by different social, cultural, and macroeconomic conditions. There are numerous obstacles to the successful application of legal measures such as laws and global agreements. Some of the challenges include specifics in enforcement, reconciling the rights of local and indigenous communities with developmental objectives, and shortcomings within the current legal systems.

1. ESSENCE OF LEGAL MECHANISM ENFORCEMENT

Utilizing legal frameworks is essential for effectively preventing deforestation and forest degradation due to several key reasons, including regulatory enforcement, promotion of sustainable practices, protection of community rights and fulfillment of international obligations.

Legal systems enable the enforcement of rules designed to protect forests. They set boundaries on land use, govern logging activities, and prescribe penalties for illegal deforestation activities, which help prevent detrimental practices.

Promotion of sustainable practices is essential as legal structures could support the implementation of sustainable forest management that balances environmental, societal, and economic needs. This may include advocating for responsible harvesting techniques, preserving biodiversity, and ensuring that forest resources are used in a way that benefits both local communities and the environment.

Legal mechanisms are critical in defining and safeguarding the rights of indigenous and local communities who rely on forests for their livelihoods. Recognizing these rights legally empowers these communities to sustainably manage their resources and defend their lands from external encroachments.

Through legal means, countries can adhere to international environmental and climate agreements, such as the Paris Agreement and the Convention on Biological Diversity. Implementing international environmental and climate agreements through national laws makes them more actionable. Legal frameworks must ensure that forest conservation efforts are coordinated and consistent across various government levels and sectors, aligning local actions with broader national and international objectives. This requires specific policy coordination.

Legal frameworks are fundamental to forest protection because they establish enforceable regulations, encourage sustainable management, secure community rights, uphold international commitments, facilitate coordinated conservation activities, and guarantee the sustainability of conservation initiatives. These aspects underscore the significance of legal systems in effective environmental governance and forest protection strategies.

European Union legal framework for preventing deforestation and forest degradation requires essential intersectoral coordination and international collaboration. Forest degradation and deforestation along with environmental challenges often are caused by complex factors and dealing with existing threats to the world's forests extend beyond national borders, making international collaboration vital. Legal integration should be in line with regional and global environmental standards and agreements, as at the same time legislation needs to be flexible.

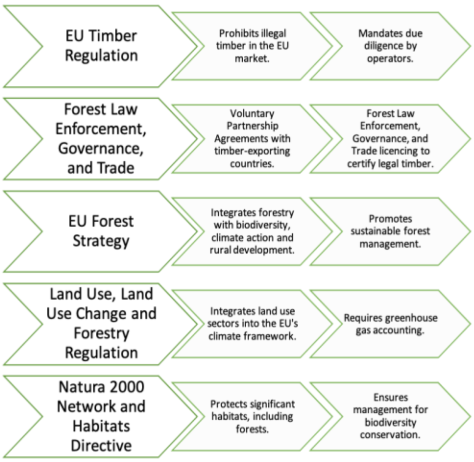

Figure 1. EU Legal Framework for Preventing Deforestation and Forest Degradation

Combat forest degradation and deforestation may involve very specific and complex approach to be applied as legislative context and implementation requires to consider elements such as diversity, enforcement challenges, specific climate issues, forestry sector developments, etc.

Analysis focusing on the legal mechanisms used in Europe, with a specific emphasis on Bulgaria, to combat deforestation and forest degradation reveals that Bulgaria and Europe have substantial legal frameworks in place and are able to address deforestation issues even though Bulgaria does not have its own specific legal act strictly related to deforestation.

Bulgaria has adopted a National Climate Adaptation Strategy and 2023 Action plan, as the country's strategy outlines climate changes risks and vulnerabilities of multiple sectors. By the end of 2023 a Strategic plan for development of the forest sector in Bulgaria has been applied, as it classifies and identifies activities aimed to achieve objectives focusing to activities in accordance with the principles of sustainable forest management, reducing deforestation.

Bulgaria, renowned for its diverse ecosystems and vast forested areas, is grappling with significant deforestation issues that threaten its ecological stability and conservation efforts. Deforestation in Bulgaria is driven by multiple factors such as illegal timber harvesting, agricultural development, construction activities and also wildfires. The impact of these deforestation activities includes the loss of animal habitats, diminished biodiversity, and disruption of natural processes such as water regulation and carbon storage, which can exacerbate climate change effects.

The nation's involvement in the European Union's Natura 2000 network is crucial to its strategies for mitigating these environmental challenges. Numerous areas within Bulgaria are designated under Natura 2000, protecting a substantial portion of the country's forests. Such protected areas are vital for the conservation of diverse species, including some that are endemic or critically endangered. Management of these areas adheres to stringent guidelines designed to balance human activities with the need for ecological preservation. Being part of Natura 2000 provides Bulgaria with access to EU funds and expertise, which help in managing protected areas and addressing deforestation.

Bulgaria continues to enforce its environmental laws and expand protected areas under the Natura 2000 framework. However, challenges such as the need for stronger enforcement mechanisms, balancing economic development with environmental conservation, and ensuring adequate funding and resources remain. These efforts require persistent dedication and collaboration at both national and European levels to safeguard Bulgaria's natural heritage while tackling deforestation effectively.

2. REGULATORY MECHANISM INTRODUCING EU DUE DILIGENCE REGULATION

The EU Due Diligence Regulation (EUDR) is a critical legislative initiative aimed at curtailing deforestation and forest degradation associated with certain commodities entering the EU market. The EUDR mandates stringent due diligence protocols for companies importing products like soy, beef, palm oil, wood, cocoa, and coffee, which are often linked to deforestation. This regulation ensures these commodities are procured in compliance with the legal standards of the production country, including environmental laws.

Regulation (EU) No. 995/2010 also known as EU Timber Regulation (EUTR) prohibits illegally harvested timber from being placed on the EU market, and sets out preconditions for the marketing of timber and timber products in the EU. This is part of a wider legislative framework which the European Commission considered to only partially address deforestation. By development of the legal framework the EU Timber Regulation has been repealed by Regulation (EU) 2023/1115 adopted by the co-legislators on 31 May 2023 - aimed at tackling deforestation and forest degradation driven by the European Union (EU). At European union level the new EU Deforestation regulation will apply in full as of December 30th 2024. Coming into force the new regulatory policies will definitely affect the European forestry market.

Detailed analyses of the regulatory mechanism reveal its complex structure implementing legislative norms related not only to due diligence, but also to product checks and control regulations, human rights protection challenges management and penalties enforcement procedures.

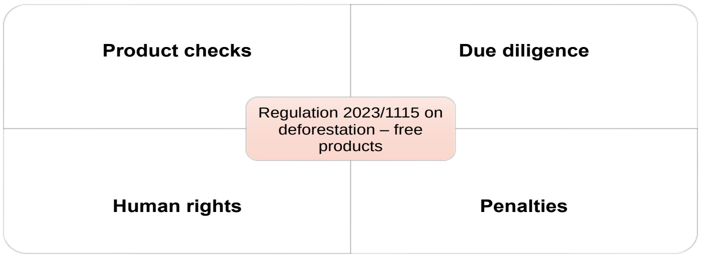

Figure 2. Fighting deforestation and forest degradation – EU Regulatory Mechanism

Key mechanisms of the European Union Due Diligence Regulation in combating deforestation involves mandatory due diligence, supply chain transparency, risk management, regulatory oversight and international support. Companies must prove their products and are legally sourced according to the laws of the origin country, especially those concerning forest conservation. Companies are required to keep comprehensive records about their supply chains to enhance transparency and allow verification of product origins and compliance with environmental standards. They must evaluate the potential risks their supply chains pose to forests and take steps to reduce these risks, potentially by switching suppliers or promoting sustainable methods. In regards to regulatory oversight the EU introduces enforce compliance through routine reporting and auditing, with potential penalties including fines or market access restrictions for non-compliance. The regulatory mechanism introduced into the EU legal framework requires implementation of provisions for aiding producing countries in improving their environmental governance and collaborating with them to uphold forest protection laws.

Furthermore, the strategies and frameworks of the EUDR could be adapted for global application to more effectively combat deforestation and forest degradation. Implementing similar regulations worldwide could establish a unified standard for deforestation-linked products, significantly enhancing their impact. International agreements and cooperative efforts could reinforce the enforcement of such regulations, addressing deforestation and forest degradation more comprehensively. These adaptations could position the EUDR as a blueprint for other countries and regions, aiming to cultivate a sustainable global trading system that prioritizes the conservation of natural forests.

3. CROSS-SECTORAL LEGAL INTEGRATION FOR FOREST CONSERVATION

Sectors traditionally viewed as unrelated to environmental impact, like finance and trade, need also to implement regulations that take ecological consequences into account. Effective forest conservation necessitates that environmental concerns could be integrated into all industrial and developmental policies. Implementing effective cross-sectoral legal integration for forest conservation involves harmonizing policies and regulations across various sectors impacting forest management. This ensures that development and conservation efforts are aligned.

Cross-sectoral integration of measures targeting forest conservation includes differentiated approach and multilevel coordination as activities involve specifics directed to policy development and legal framework establishment. Coordinated institutional efforts are required to be put forward, as engagement of all stakeholders are also required within the process of cross-sectoral legal integration. The success of this entire process involves an engagement of a broad array of stakeholders, including community groups, NGOs, industry leaders, and researchers. Adopting relevant approach requires solid commitment from political leadership, adequate funding, and dedication to long-term environmental sustainability.

Results of integrating legal frameworks across sectors could result to consolidated regulations. A key result is the creation of consolidated regulations that bring different sectors like agriculture, mining, and construction into alignment with forest conservation objectives. This involves formulating laws that dictate land use and promote sustainability.

Integrating legal frameworks leads to more effective enforcement and compliance mechanisms, enhancing adherence to laws related to deforestation and conservation. This might include coordinated efforts across various regulatory authorities.

Promoting partnerships between government and the private sector can lead to innovative approaches to managing forests sustainably and developing responsible supply chains.

Successful integration often highlights the importance of involving local communities in conservation efforts, acknowledging their rights and leveraging their traditional knowledge in sustainable forest management.

Adopting cross-sectoral strategies often includes the use of advanced technology for improved monitoring and enforcement, such as using satellite imagery and blockchain for tracking supply chains.

Cross-sectoral integration is essential and must continually evolve to meet new environmental challenges, economic shifts, and societal expectations to ensure effective and lasting forest management.

4. CONCLUSIONS, CHALLENGES AND FUTURE PERSPECTIVES

Legal measures are essential in the global effort to combat deforestation and forest degradation. These regulations, enacted on both national and international levels, aim to protect crucial forest ecosystems, which support biodiversity and climate stability.

Properly structured and implemented, legal frameworks can greatly deter illegal logging and other deforestation activities. Laws that enforce sustainable use of land, protect rights to indigenous territories, and control land clearance can yield significant conservation results. Successful legal interventions in forest conservation contribute to biodiversity preservation, help combat climate change and support the economies of communities reliant on forests.

Legal measures to curb deforestation often collide with strong economic interests from sectors like agriculture, logging, and mining. Balancing environmental sustainability with economic growth remains a contentious issue. A major hurdle is the actual enforcement of conservation laws. Challenges such as lack of funding, corruption, inadequate monitoring and enforcement infrastructure, as well as lack of political commitment can undermine legal efforts.

Legal frameworks frequently neglect to involve local and indigenous populations adequately in policymaking, which can lead to opposition and weakened enforcement of forest protection laws. Legal approaches should better incorporate local and indigenous communities, who have intrinsic knowledge of forest ecosystems and can contribute to sustainable management.

While there are significant challenges in using legal mechanisms to combat deforestation and forest degradation, ongoing advancements and strategic innovations offer promising solutions for more effective forest conservation worldwide. These initiatives require collaborative efforts among governments, international organizations, community groups, and the private sector to achieve lasting success.

REFERENCES

1. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – New EU Forest Strategy for 2030*, (COM(2021) 572 final, 16.7.2021)
2. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – EU Biodiversity Strategy for 2030 – Bringing nature back into our lives*, (COM(2020) 380 final, 20.5.2020).
3. European Commission, DG Environment, The Natura 2000 Newsletter 2022 ,Public office of the European Union, Luxemburg, ISSN: 2443-7727
4. EU Monitor (2012), *Implementing regulation 2012/607 - Detailed rules concerning the due diligence system and the frequency and nature of the checks on monitoring organizations as provided for in Regulation 995/2010 laying down the obligations of operators who place timber and timber products on the market*, OJ L 77/16, 7.7.2012
5. Ministry of Environment and Water of the Republic of Bulgaria, *Environmental Protection Act*, State Gazette No. 91/25.09.2002.
6. Neykova, M. (2018): *Analysis of the Regulatory Framework Governing the Administrative Service*, International Scientific and Practical Conference World science. Vol. 8 No. 6, pp. 46-50.
7. Neykova, M., (2017): *Changes in the administrative procedure code and principles of the complex administrative servicing*., Globalization, the State and the Individual, No 2(14)/2017, s. 79–83
8. Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010 laying down the obligations of operators who place timber and timber products on the market, OJ L 295, 12.11.2010, p. 23–34
9. *Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010,* (OJ L 150, 9.6.2023, pp. 206–247).
10. Zahariev, M., Makshutova, R. (2020); *GDPR Implementation Series: Bulgaria; European Data Protection Law Review (EPDL)*, Berlin, 2020, Lexxion Verlag, Volume 6, Issue 3, pp. 424-432, ISSN 2364-2831

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KNOWLEDGE AND PERCEPTION OF THE CIRCULAR ECONOMY WITHIN SLOVAK FOREST-BASED INDUSTRY AND COMPARISON OF CHOSEN INDICATORS IN SELECTED EU COUNTRIES

Marek Potkány, Petra Lesníková, Jarmila Schmidtová, Mária Osvaldová

Abstract: In many countries and organizations, policies and programs are being developed to support the circular economy (CE) concept with the aim of reducing the negative impact on the environment. Perception of CE may differ, and therefore the aim of the paper is to present the knowledge and perception of the circular economy essence in Slovak forest-based industry. Moreover, the aim is also the comparison of main CE indicators of V4 countries and Bulgaria. The origin of the indicators and their subsequent use is the result of efforts to find solutions within the growing environmental burden, support sustainability, and especially monitor the progress of their implementation for the CE concept.
Keywords: circular economy, perception, indicators, wood processing industry, V4 countries, Bulgaria

1. CIRCULAR ECONOMY AS A SUSTAINABLE PRODUCTION PERSPECTIVE

The gradual reduction of resources, their inefficient use and growing consumption emphasize the necessity of implementing circular economy (CE), which helps the path to sustainable development (Alivojvodic and Kokalj, 2024). For several years, terms such as sustainable development, CE, bioeconomy or green economy have been used more and more often. It is possible to say that these are related concepts, but their perception may be different. European Parliament (2023) defines the CE as “a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended. In practice, it implies reducing waste to a minimum”. According to World Economic Forum (White Paper, 2023), the CE represents a $4.5 trillion opportunity by 2030. Its potential is therefore obvious. From the point of view of the mentioned concepts, the green economy can be perceived as a more general concept, taking into account that the CE and the bioeconomy are its components (Gregorio et al., 2018). While the bioeconomy focuses on “using renewable biological resources from land and sea, like crops, forests, fish, animals and micro-organisms to produce food, materials and energy” (European Commission), CE deals with the efficient use of all resources and the minimization of waste through recycling and reuse. Both approaches intermingle, their common goal is achieving sustainable development. The synergy of these two concepts is expressed in the term "circular bioeconomy", which can be defined “as the sum of all activities that transform biomass for use in different product streams such as materials, chemicals, biofuels, and food“ (UNECE, 2021, p. 23). Several researches were focused on the perception of CE, while stakeholders from various fields were addressed. An example is the research by Geme et al. (2023), from which it follows that only 27% of respondents know the given term and a little over 60% of respondents pointed out that they had only heard about CE and understood only the basics of this concept. Similarly, Sijtsema et al. (2019) confirms that respondents do not know the exact meaning of CE and ignorance prevails. Several indicators are associated with CE. Their essence is the providing of measurement that allow monitoring and evaluation of success and progress in the pursuit of CE objectives. Many organizations deal with the issue of CE indicators, e.g.the Statistical Office of the EU (ec.europa.eu); OECD (www.oecd.org); Ellen Macarthur Foundation (www.ellenmacarthurfoundation.org); World Business Council for Sustainable Development (www.wbcsd.org).

2. DATA AND METHODOLOGY

The paper aim is (1) to evaluate the knowledge and perception of the concept of CE of interested groups in the sector of the forestry and timber complex in the Slovak Republic; and also (2) to compare selected CE indicators in the V4 countries and in Bulgaria. For data collection related to the perception of the CE, a questionnaire survey was used. Data collection took place in the period October 2023 - January 2024 in the Slovak and Czech Republic.

The data for analysis of selected CE indicators is drawn from the Eurostat database (ec.europa.eu). Two indicators were analyzed in the paper. Circular material use rate (section of Secondary raw materials) measures the share of material recycled and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. The second indicator, Private investment and gross added value related to CE sectors (section of Competitivennes and innovation) includes “Gross investment in tangible goods” and “Value added at factor costs” in the recycling, repair and reuse and rental sectors. Interdependence was investigated with the macroeconomic indicator GDP per capita adjusted according to purchasing power. The objects of the analysis are the countries of the V4 group and Bulgaria for the years 2011 to 2021. In the current study, the following hypotheses were set: H1: Countries with higher private investment and gross added value related to CE sectors achieve higher performance measured through GDP (in PPS) and H2: Countries with higher performance measured through GDP (in PPS) achieve a higher circular material use rate.

To consider how the value of one variable varies with the value of another variable simple regression and correlation analysis was applied. Regression coefficients of linear model $Y = b_0 + b_1X$ were estimated using the method of least squares according to the given formulas:

$$b_1 = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2} \ (1) \qquad b_0 = \bar{Y} - b\bar{X} \ (2)$$

b_0 – intercept, b_1 – slope, X – observed values of independent variable, Y associated observed values of dependent variable, $\bar{X}, \bar{Y}$ – their means, n – sample size.

The Pearson’s coefficient of correlation R defined as follows was used to assess the degree of association between two investigated quantitative variables:

$$R = \frac{\sum XY - n\overline{XY}}{\sqrt{(\sum X^2 - n\overline{X^2})(\sum Y^2 - n\overline{Y^2})}} \ (3)$$

The coefficient of determination R^2 was finally calculated. It is a statistical measure that provides information about how well the regression line approximates the actual data and is expressed as the proportion of the variability explained by the model to the total variability. In hypothesis testing 5% level of significance was used as a decision rule. All analyses were performed in statistical software STATISTICA 14.

3. RESULTS

3.1. Perception of the CE concept in the field of forest-based industry

When analyzing the knowledge and perception of the CE concept, the sample of respondents consisted of 68.50% men and 31.50% women from a total number of 130. In terms of age, the most represented categories were respondents aged 46-60 years (38.50%) and 31-45 years (33.10%). Less represented categories were respondents aged 18-30 (16.60%) and 61 and over (11.50%). Most of them were university-educated respondents (86.20%), secondary-educated respondents (13.10%) and only 1 respondent had a basic education. The wood processing industry (32.31%) and forestry (24.62%) was the most represented. Other areas were represented to a lesser extent: education (6.92%), paper industry (3.85%), and the environment and so on. The results show that among the respondents, sustainable development and circular economy are the more familiar terms, followed by bioeconomy, where there was the highest frequency of ignorance of the term (Table 1).

Table 1. Comparison of knowledge of the CE term with other terms

I have heard the term and I know what it means			
	Circular economy	Sustainable development	Bioeconomy
Agree	95 (73.1%)	102 (78.5%)	63 (48.5%)
Partly agree	27 (20.8%)	26 (20.0%)	41 (31.5%)
Do not agree	8 (6.2%)	2 (1.5%)	26 (20.0%)

More university-educated respondents (89), and more men (66) than women (29), and respondents aged 31-45 (33) and 46-60 (36) know the CE concept. The results also show that most respondents understand the CE as an important part of sustainable development (104). The compatibility of the CE with other economic concepts that are supposed to mitigate climate change and improve adaptation to climate change is perceived by 95 respondents, 3 disagree.

Using the sample data, the relationship between indicator 1 and GDP per capita was considered at first. The straight line that concisely summarizes the investigated depencence was modelled and thereafter tested at 5% significance level. Detailed results of regression analysis for Bulgaria and countries of V4 are presented in Table 2.

In the context of H1, in all cases significant positive linear relationship was indicated. The lines of best fit for singe countries are illustrated in Figure 2. The steepest growth is observed in Bulgaria with the biggest value of slop in regression equation $Y=7\ 917.93 + 18{,}68*X$. With a unit change (one million Euro) of private investment and gross added value, the GDP increases by an average of 18.68 units. Among the countries of the Visegrad Group, Poland stands out of the rest with the value of the slope coefficient 2.08.

3.2. Analysis of selected CE indicators of the V4 countries and Bulgaria

Figure 1 approximates the development of indicators as Private investment and gross added value related to CE (indicator 1) and Circular material use rate (indicator 2).

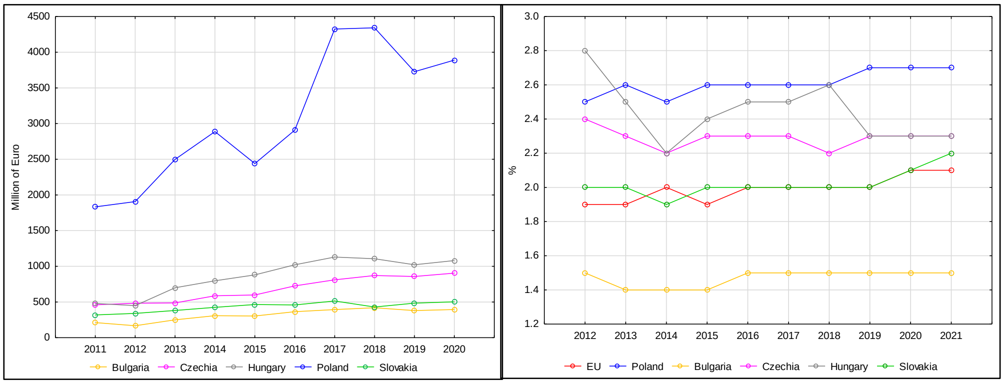

Figure 1. Development of the indicator 1 (left) and indicator 2 (right) over the analysed years in the V4 countries and Bulgaria

Table 2. Results of simple linear regression analysis – Indicator 1 versus GDP per capita

Country	Indicator	Mean ± St.Dev.	N	Intercept	Slope	t-test	p-level
BG	Private investment	319.2±86.3	10	7 917.93	18.68	4.98	0.001
	GDP	13 880.0±1 854.0					
SK	Private investment	431.9±66.7	10	16 148.16	11.07	3.82	0.005
	GDP	20 930.0±919.0					
CZ	Private investment	678.6±175.7	10	14 284.55	15.81	12.87	0.000
	GDP	25 010.0±2 843.5					
HU	Private investment	866.6±253.3	10	13 527.83	7.05	4.53	0.002
	GDP	19 640.0±2 105.7					
PL	Private investment	3 075.9±940.6	10	13 100.81	2.08	4.50	0.002
	GDP	19 490.0±2 307.2					

Statistics determining the strength of the described relationships and the share of variability explained by the linear model are given in Table 3. A positive linear correlation is the strongest in the Czech Republic with correlation coefficient of 0.98. The value of the coefficient of determination is therefore the highest too – 95% of the total variation of GDP can be explained by the regression line. In linear model fitting the smallest values of R and R^2 were calculated for Slovakia, where regression line explains 65% of the total variability of GDP.

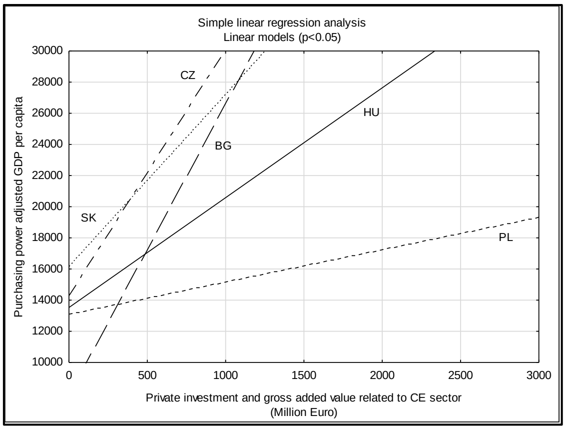

Figure 2. Line chart – the relationship modelled by regression line between variables Private investment and gross added value related to CE sector and GDP per capita

Table 3. Results of correlation analysis – Indicator 1 versus GDP per capita

Country	R	R^2
BG	0.87	76%
SK	0.80	65%
CZ	0.98	95%
HU	0.85	72%
PL	0.85	72%

The relationship between variables GDP per capita and indicator 2 (H2) was also investigated in a similar way. From results presented in Table 4 significant linear relationship were indicated in two countries – Slovakia and Poland – in both cases positive. With the unit growth of GDP, the circular material use rate also grows, on average by 0.00005% in Slovakia and 0,00002% in Poland. In the other countries, a significant linear dependence was not observed ($p>0.05$). The results for Bulgaria could be considered as a boundary case ($p=0.056$).

According to the values of correlation coefficient R for the countries SK ($R=0.79$; $R^2=62\%$) and PL ($R=0.86$; $R^2=74\%$), linear correlation in Poland was determined as strong ($R>0,80$) and in Slovakia it was determined as medium size ($R>0,70$). The values R^2 reflect how well the estimated regression lines fit the sample data. In the case of Poland, 74% of total variation is explained by the linear model, for Slovakia the value of coefficient of determination is 62%.

Table 4. Results of simple linear regression analysis –GDP per capita and indicator 2

Country	Indicator	Mean±St.Dev.	N	Intercept	Slope	t-test	p-level
BG	GDP	14 560±2 183.4	10	1.27	0.00001	2.23	0.056
	Cir.mat. use rate	1.47±0.1					
SK	GDP	21 360±1 192.8	10	0.91	0.00005	3.63	0.007
	Cir.mat. use rate	2.02±0.1					
CZ	GDP	25 850±2 962.5	10	2.41	-0.000005	-0.72	0.490
	Cir.mat. use rate	2.29±0.1					
HU	GDP	20 360±2 390.4	10	3.17	-0.00004	-1.57	0.155
	Cir.mat. use rate	2.44±0.2					
PL	GDP	20 340±2 697.8	10	2.13	0.00002	4.83	0.001
	Cir.mat. use rate	2.61±0.1					

4. CONCLUSION

Currently, there is a significant trend in many research studies towards CE. This is evidenced not only by the priority among topics within the EU, but also by the understanding of the CE essence among survey respondents in Slovakia, whereas 73% of respondents know the CE concept. Similar results are presented in the study by Geme et al. (2023). However, there are still certain limitations. It is clear from the results of the survey that the respondents understand CE as an important part of sustainable development, but a more precise essence is still absent, which is also supported by the results of Sijtsema et al. (2019). From the point of view of CE indicators, Poland shows the highest private investment value related to CE. In conclusion, it can be concluded that countries with higher private investment related to CE sectors achieve higher performance. Investments in technology, infrastructure and innovation in CE areas can lead to more efficient use of resources, higher productivity and job creation leading to higher business performance. Subsequently, countries with higher performance also achieve a higher circular material use rate (significantly tested in PL and SK), which indicates that a higher GDP also supports an increase in the share of material recycled and fed back into the economy. These approaches thus support the transition from a linear model of the economy to a circular model, support sustainability and especially strengthen environmental protection. This is important in terms of access by the current generation and possible legacy to future generations.

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REFERENCES

1. Alivojvodic, V.; Kokalj, F. (2024): *Drivers and Barriers for Adoption of Circular Economy Principles towards Efficient Resource Utilization.* Sustainability 16 (3): 1317. https://doi.org/10.3390/su16031317
2. Ellen Macarthur Foundation. *Delivering the Circular Economy: A Toolkit for Policymakers*. URL: https://emf.thirdlight.com/file/24/neVTuDFno5ajUene-man5IbBE/Delivering%20the%20circular%20economy%3A%20a%20toolkit%20for%20policymakers.pdf
3. European Commission: *Research and Innovation Bioeconomy*. URL: https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy_en?prefLang=sk
4. European Parliament (2023): *Circular economy: definition, importance and benefits*. URL: https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits
5. Eurostat. Circular Economy Database. URL: https://ec.europa.eu/eurostat/web/circular-economy/database
6. Geme, T.; Nijman, E.; Ntawuhiganayo, E.B.; Negesa, D. (2023): *Stakeholder knowledge and perceptiosn of the circular economy in Ugandan cities*. Frontiers in Sustainability 4. https://doi.org/10.3389/frsus.2023.1117814
7. Gregorio, V.F.; Dols, L.P.; Terceño, A. (2018): *A Systematic Literature Review of Bio, Green and Circular Economy Trends in Publications in the Field of Economics and Business Management.* Sustainability 10 (11): 4232. https://doi.org/10.3390/su10114232
8. OECD. (2021): *The OECD Inventory of Circular Economy indicators*. URL: https://www.oecd.org/cfe/cities/InventoryCircularEconomyIndicators.pdf
9. Rótolo, G.C.; Vassillo, C.; Rodriguez, A.A.; Magnano, L.; Milo Vaccaro, M.; Civit, B. M.; Covacevich, M.S.; Arena, A.P.; Ulgiati, S. (2022): *Perception and awareness of circular economy options within sectors related to agriculture in Argentina*. Journal of Cleaner Production 373. https://doi.org/10.1016/j.jclepro.2022.133805
10. Sijtsema, S.J.; Snoek, H.M.; van Haaster-de Winter, M.A.; Dagevos, H. (2019): *Let's Talk about Circular Economy: A Qualitative Exploration of Consumer Perceptions.* Sustainability 12 (1): 286. https://doi.org/10.3390/su12010286
11. UNECE (2021): *Circularity concepts in forest-based industries*. United Nations and the Food and Agriculture Organization of the United Nations. URL: https://unece.org/sites/default/files/2021-11/Circularity%20concepts%20in%20forest-based%20industries.1108.pdf
12. White Paper (2023): *Climate Governance and the Circular Economy: A Primer for Boards.* World Economic Forum, October 2023. URL: https://www3.weforum.org/docs/WEF_Climate_Governance_and_the_Circular_Economy_2023.pdf
13. World Business Council for Sustainable Development. *Circular Transition Indicators (CTI).* URL: https://www.wbcsd.org/Programs/Circular-Economy/Metrics-Measurement/Circular-transition-indicators

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PERSPECTIVES FOR THE DEVELOPMENT OF FOREST-BASED BIOECONOMY FOR INCREASING SUSTAINABILITY IN BULGARIA

Damyan Kirechev, Velichka Marinova

Abstract: The bioeconomy is aimed at achieving important goals aimed at ensuring food security, sustainable management of natural resources, reducing dependence on non-renewable resources, mitigating and adapting to climate change. In recent years, the potential of the forest-based bioeconomy to ensure competitiveness, diversification and sustainability of the economy has been increasing. The forest-based bioeconomy is influenced by the availability of biomass, quality labour force, employment and the structure of the economy, innovation uptake, etc. The study examines the potential of the forest-based sector for the development of the bioeconomy in Bulgaria, in the context of the European Forestry Strategy and the state of the forestry sector in the country. Emphasis is placed on the contribution of forests to the circular economy, including the improvement of forest-based bioproduction, the use of timber in construction and furnishing, and the supply of non-timber forest products. Conceptual options for unlocking the potential of the bioeconomy through the creation of innovative wood-based products, enhancing the resilience of the forest bioeconomy and climate adaptation and mitigation are explored.
Keywords: bioeconomy, circular bioeconomy, forest sector, sustainability, climate change.

1. THE FOREST SECTOR IN THE BIOECONOMY

1.1. Bioeconomy as a development strategy in the European Union

The 2018 EU Bioeconomy Strategy defines the bioeconomy as "those parts of the economy that use renewable biological resources from land and sea, such as crops, forests, fish, animals and micro-organisms, to produce food, materials and energy" (European Commission, 2018). Today's European bioeconomy encompasses agriculture, forestry, fisheries, agri-food, bioenergy and bio-products sectors. It generates an annual turnover of €2.3 trillion and employs around 18 million people. Although the bioeconomy already accounts for a significant share of the EU economy, the strategy signals its potential to contribute even more to the economy, more to society and more to the environment. A sustainable bioeconomy, while beneficial for all, has particular relevance for rural communities (Branzova, 2019). The policy impetus behind the bioeconomy is focused on job creation and retention; reduced emissions and reduced reliance on fossil resources; a renewed and strengthened EU industrial base and modernised primary production, as well as ecosystem restoration and enhanced biodiversity.

1.2. Prospects for the forest sector in the bioeconomy

The outlook for the forest sector is of great importance because of the impact the sector has on the state of forests and the benefits they provide, such as forest products, energy, employment, biodiversity, carbon cycling and water management. Without an understanding of the demand for forest products, it is very difficult to assess the impact that strategies and policies may have on the forest sector or on society.

Forests can play an important role in promoting the local bioeconomy. They are the dominant land use after agriculture and are the largest source of terrestrial biological resources that do not compete with food production. They are the largest green infrastructure, provide a large array of ecosystem services, and play a significant but undervalued role in the economy. Significant synergies can be achieved through effective management, including reduced wildfire risk, provision of ecosystem regulating services (e.g. erosion control, water regulation, drought mitigation).

The forestry sector can play a key role in the development of a forest-based bioeconomy if it can overcome its fragmentation and technological constraints, which particularly affect local wood industries that are typically in low-value commodity market segments and are usually decoupled from higher-value-added segments (e.g. wood structures) that typically depend on imported wood and manufactured wood products. Closer collaboration between forestry and agriculture is needed (Slavova & Doneva, 2022), to advance the bioeconomy.

Each sector faces specific hurdles that need to be identified and systematically removed, so the critical question is not what can be made from forest biomass, but rather what will be made, at what scale, where, and what will drive it? Creating an enabling environment for forest bioeconomy development requires: 1) an engaged, well-informed public; 2) strong, reassuring sustainability schemes; 3) adequate capacity for research, development and innovation; 4) improved access to finance and capacity for risk-taking; 5) an enabling regulatory environment capable of correcting current perverse subsidies and market externalities; 6) enhanced collaboration along the value chain and across sectors; 7) a sustainable and well-functioning biomass supply; and 8) a regional approach capable of creating economies of scale, making the most of available natural resources and reflecting people's aspirations and regional competitive advantages.

1.3. Role of the forest sector in the bioeconomy

The role of forests and the forestry sector is often seen as a supplier of timber, pulp, paper and some bioenergy, which represent a small percentage of the economy (Kirechev, Stoyanova, & Marinova, 2023). However, new technologies, business models and consumption patterns are creating opportunities for the forest sector to make a much greater contribution to sustainable development (R. & A., 2023).

The forestry sector is already undergoing major structural changes and diversification into the production of advanced materials that can help transform key economic sectors such as energy, construction and manufacturing (textiles, plastics, pharmaceuticals, cosmetics, etc.). This knowledge-rich portfolio of current and future products will require specialised services (design, research and development, consultancy, marketing, sales, etc.). (Ventsislavova Georgieva & Popova-Terzyiska, 2023), which further multiply its economic impact. In addition, forests provide key ecosystem services to society, such as cultural services (recreation, ecotourism, hunting, health), regulating services (clean air, erosion control, climate mitigation) and providing services (clean drinking water, non-timber forest products such as mushrooms and berries). Forests can produce goods and services for the bioeconomy only if extreme climatic events or unsustainable management do not alter their biological integrity. This twosided contribution of forests to the bioeconomy and its feedback loops should be an important element in the design of the circular bioeconomy (Turlakova, Slavova, & Georgieva, 2023).

1.4. Forest Capacity in Bulgaria and Forest Bioeconomy

According to the Bulgarian Ministry of Agriculture and Forestry (Ministry of agriculture and food, 2023) the total area of forests and forest areas in Bulgaria at the end of 2022 is 4.27 million ha, of which 3.93 million ha are forested. The area of forest areas is 3.95 million ha, of which 2.89 million ha (73.1%) are forest areas managed by state-owned enterprises, 172 thousand ha (4.4%) are protected forests and only 381 thousand ha (9.6%) of forest areas are owned by individuals. The forested area is 3.92 million ha. The forested area in forest areas is 3.61 million ha. The distribution of the forest stock shows - 44% are coniferous forests, 31% are high standing deciduous forests, 23% are coppice forests and 2% are low standing forests. The general use of regeneration loggings and thinnings for the forest territories, carried out in 2022, amounted to 7,644,163 cubic meters of standing mass, which is equal to 94.5% of the foreseen under the forestry plan (forest development project) 8,091,492 cubic meters of standing wood. Of these, 3,880,949 cubic meters were from regenerative felling. The implementation of the regenerative felling compared to the planned ones according to the forestry plan (4,623,648 cubic meters) was 83.9%. 3,763,214 cubic meters were harvested from thinnings, which was 108.5% of the one envisaged in the forestry plan (3,467,844 cubic meters). The annual use in the forest territories - state property amounted to 5,943,365 cubic meters of standing mass or 94.7% of the 6,278,419 cubic meters of standing mass. The annual use of forests on agricultural areas is in the amount of 94,139 cubic meters of standing mass.

According to the Joint Research Centre (Joint Research Centre, n.d.) in 2021 in the bioeconomy in Bulgaria the number of employees is 726.2 thousand and the added value is for € 5.5 billion. The turnover of the bioeconomy sector is almost € 18 billion. In the forestry sector, the number of employees is 21.7 thousand (3%) and the value added is € 272.6 million (5%). The turnover of the forestry sector is about 458,7 million € (only 2,5%).

2. CONTRIBUTION OF FORESTS TO THE CIRCULAR BIOECONOMY

The potential contribution of forests and forestry to the circular bioeconomy, sustainability and competitiveness can be sought in many directions, and this study focuses on three key sectors: 1) advanced forest-based bioproducts; 2) timber and furniture construction; 3) non-timber forest products.

2.1. Products and technologies

Biotechnological materials from wood. The biotechnology revolution and the need to tackle climate change, pollution and waste over-accumulation are creating the impetus for a new generation of bio-based materials that will redefine the characteristics and limits of the current forest sector. The opportunities for bio-based products are not limited to bio-textiles and bioplastics. Wood is a major component in cellulose (35%-50%), hemicellulose (20%-35%) and lignin (5%-30%), which are common natural polymers on Earth. With varying degrees of engineering, solid wood can be used as a manufacturing material and energy feedstock. The woody components can be processed through various chemical routes and converted into biotechnology products. The choice of fractionation, product recovery, purification and conversion depend on the type of biomass and the target products.

Lignocellulosic biomass is well placed to play a significant role in replacing fossil-based textile products because of the quality of the fibres that can be produced. Its environmental footprint is much smaller than cotton (e.g., water, pesticides, competition for agricultural land). Cellulosic fabrics already account for 7% of all fibres and demand is expected to grow significantly over the next few decades. Addressing these environmental issues will create new opportunities for the forest sector.

Currently, most biopolymers and building blocks are produced from plant sugars and vegetable oils (first generation feedstocks) derived from specialty crops and, to a lesser extent, agricultural or post-consumer residues. Lignocellulosic or second-generation feedstocks are a promising source of sugars (cellulose, hemicellulose) because of their abundance and because they can compete less with food production. However, lignocellulosic industrial technologies still need time to mature to compete with better established sugars, starches and oils. Once extracted, celluloses and hemicelluloses can be hydrolysed, becoming fermentable sugars that can replace first-generation sugar feedstocks (e.g. corn, sugarcane, etc.) in the production of biofuels, polymers, bioplastics and chemical building blocks. A second very active area of interest is the engineering of microorganisms for fermentation tailored to specific feedstocks and end products, which will open up new markets for highly specialised products.

Agricultural and forest biomass makes up to 30% of the mass and 40% of the energy content of lignin. Lignin is a by-product of pulp mills. Contrary to what happens with cellulose and hemicellulose, its structure varies from species to species (e.g. softwood vs. hardwood) and also changes during fractionation.

Construction of timber. Greening the construction sector is a key challenge for sustainable development. A more sustainable building sector requires increased use of low embodied energy materials such as timber and cork, as well as improved environmental performance (e.g. passive house standards) in new buildings and extensive retrofitting of older structures. There are some drivers that are pushing for the renewal of timber buildings: there is political momentum to develop a more sustainable building sector as a whole as part of the energy transition; timber has inherent advantages; timber structures require relatively small amounts of timber and new elevating work platforms can be developed based on many different species and qualities of timber. The positive effects of developing a new way of building in small and large cities based on timber resources will outweigh the expected environmental benefits. It can tangibly improve rural well-being, generate local material value chains for residues. Active rural areas will be able to generate additional income in the tertiary sector through things like ecotourism and this could be an incentive to expand and protect forest areas.

Within the framework of EU regulations, local and national authorities should encourage the use of local timber, and consumers who comply with these guidelines will reap tangible benefits. The first step should be to create a level playing field for construction markets by removing unnecessary barriers from national building regulations. Although timber construction can be directly supported (e.g., by setting mandatory targets), perhaps more could be gained from more stringent regulation of environmental performance for construction (e.g. energy efficiency, circularity) as this would make timber construction more cost-effective without displacing other existing technologies and materials. Attention must be paid to developing efficient supply chains, in some cases upgrading the technological capacity of sawmills and in other cases facilitating investment in advanced elevating work platforms. Increased R&D and innovation will be needed to link existing and new wood processing capacity to the use of local wood resources.

Non-timber forest products. Non-timber forest products are products of organic origin other than wood from forests, wooded land and trees outside forests (e.g. berries, mushrooms, cork, cedar nuts, acorns, chestnuts, resin, medicinal herbs, essential oils, honey, etc.). They play an important role in rural economies. Non-timber forest products are closely linked to cultural heritage and territorial identity. Wild medicinal plants still represent an important source of genetic material for the development of the pharmaceutical, chemical, cosmetic and food industries. Others are new, emerging products such as new drinks or edible plants and insects. In addition, changing market conditions are reopening opportunities for old, almost abandoned products such as resin and chestnut tannin. Some non-timber forest products are produced through dedicated forest management, albeit with different management intensities (e.g. cork, resin, nuts in certain regions), while others, commonly referred to as wild forest products, are harvested but not actively managed. This is the case for many mushrooms and berries, but also for some honey and medicinal or ornamental plants. Both types of non-timber forest products have significant potential to contribute to the bioeconomy, even if they require very different approaches and strategies. From a bioeconomy perspective, one major and distinct role of wild non-timber forest products is their potential to bring socio-economic well-being and a more balanced rural-urban relationship. The positive effects of outdoor forest activities on human health are attracting increasing attention and may prove to have significant economic effects on health savings. The problems with these products are market-based, difficult to describe and monitor, informal collection rules exist, and tracking their origins is difficult.

2.2. Unlocking the potential of forests for the bioeconomy

The forest bioeconomy should create prosperity and well-being while reducing the environmental footprint. This will require technological, social and policy innovation to develop new value chains, forest commodity-based services and a strong resilience framework; to protect and enhance natural capital, with a special focus on climate change adaptation and mitigation. The bioeconomy can create a strong market force for forest goods and services. This demand needs to be matched by adequate supply, albeit with active management at the landscape level, to create sustainable and thriving landscapes, balancing the provision of multiple ecosystem services.

2.2.1. Creation of innovative bio-based products

A number of conditions are needed to enable the development of the potential of bio-based products and services. These can be summarised as: strong sustainability schemes; engaged societies; knowledge, innovation and skills to create circular bio-based products.

The main barriers to the deployment of industrial biotechnology are market-related (lack of public awareness, unclear standards); barriers to biomass supply (high costs, uncertain supply, competition, subsidised energy, etc.); and technological barriers. In order to overcome these barriers, actions related to securing biomass supply, innovating products and processes of available biomass, facilitating cross-sectoral linkages, increasing research capacity, skills and upgrading technological solutions, developing an enabling policy environment and access to finance and public engagement are needed.

Cross-sectoral linkages and public-private partnerships will also be needed to develop and scale up place-based approaches to realize the potential of wood products, non-wood products, landscapes (e.g. linking ecotourism and health, water provision with fire prevention, developing synergies between wood and non-wood forest products, etc.). More emphasis on socio-economic research and social innovation may be needed in addition to technological innovation (Georgieva, 2023). Improved policy framework to facilitate access to markets, de-risk investments and ensure sustainability and public support (e.g. green procurement, green taxation, etc.).

2.2.2. Sustainability of the bioeconomy

The bioeconomy relies on natural resources for energy, material production, nature-based solutions and green infrastructure. For the bioeconomy to succeed, nature and the environment must be at the core of the economic development model, sustaining the economy and people's well-being. Natural capital cannot be exchanged with man-made capital, as the two are synergistically linked. Accepting trade-offs between natural capital and economic development makes sense in a fossil fuel-based economy where economic growth is mainly fuelled by non-renewable resources and limits environmental and climate sustainability. The bioeconomy must identify and realise synergies between environmental protection and human development.

Negative effects on natural capital and the social fabric of biomass-producing regions and communities can be summarised as: risks associated with intensification; risks associated with land-use change; risks associated with social exclusion and resource grabbing.

The first key element of a sustainable bioeconomy stems from its dependence on the Earth's natural capital and its ecosystem services. Different land uses provide direct sets of ecosystem services that must also be balanced at the landscape level. The second element is the landscape/territorial approach. The bioeconomy needs a certain dimension and economies of scale. Direct farm-to-market approaches have shown their limitations even for high value agricultural products. A territorial dimension is needed. Forestry is close to this approach as production is concentrated in planted areas, whereas semi-natural forests support much lower management and production intensities. A third critical element of a sustainable bioeconomy is circular economy thinking. Positive environmental and social impacts (e.g. employment) should be maximized. The fourth key element of a sustainable bioeconomy is the need to address both production and consumption patterns.

2.2.3. Climate adaptation and mitigation

Adaptation is necessary and requires economic support to help adapt and restore forests to climate change and socio-economic scenarios. Forest policy makers and managers need to be proactive and reactive to address these challenges. Forward-looking adaptive strategies are aimed at reducing risks, increasing forest resilience and resilience, promoting forest adaptation, and preserving multiple options for dealing with huge uncertainties in the future. Adaptation strategies and the bioeconomy can support each other through three objectives: risk reduction; increased resilience; and support for restoration.

The essence of climate change mitigation is reducing carbon emissions or offsetting them with increased carbon sinks in natural or artificial reservoirs (Kirechev, Stanimirova, & Ivanova, 2023). The contribution of forests can be increased through two approaches: 1) Increase carbon stocks in various forest sinks (trees, dead wood, litter and soil) by expanding forest areas, increasing biomass and replenishing carbon in soils. This approach is generally favoured by fast-growing species, high-density stands and reduced management intensity (reduced wood extraction) to accelerate biomass accumulation. 2) Reducing emissions through increased substitution of fossil fuels and materials with a high carbon footprint with forest products that typically have a lower carbon footprint (e.g. wood, cork, natural resins): this approach focuses on carbon flows from the atmosphere to forest products and requires increased productivity and more intensive management.

The final carbon balance of woody bioenergy depends on several factors: the source of biomass (plantations, short-rotation woody plants, waste), the intensity of activities, emissions generated during silvicultural activities, harvesting and transport, and changes in forest dynamics; a recovery period depending on the productivity of the site, the forestry activities and the intensity of harvesting, as this may affect differently the growth rates of the remaining forest and reduce or increase its susceptibility to forest fires, storms, pests and diseases; alternative use of biomass; the technology, size and efficiency of energy conversion; the energy mix to be replaced.

In general, bioenergy is and can be produced in combination with other forest products and services, contributing to their economic viability (e.g. in factory or residue-based bioenergy consumption, bioenergy related to fire prevention).

3. CONCLUSION

Favourable development of the bioeconomy in Bulgaria requires overcoming a number of difficulties and challenges, but overcoming them is essential for the transition to sustainability. In this sense, the attention of stakeholders should be focused in the following directions:

1) Creating an enabling policy environment to provide certainty for investors and limit administrative procedures.

2) Improve access to finance and mitigate risk through public-private partnerships in the forest sector, long-term guarantees, green bonds, etc.

3) Transition to building integrated industrial ecosystems can create improved technology service and alliances of supply chain actors.

4) Leveraging the inherent quality and properties of forest biomass (e.g. cellulosic fibres, solid and engineered wood or cork materials, etc.) will contribute to long-term competitive advantage as these products and materials will be more easily substituted in a very dynamic technological and market landscape. They will also provide a good basis for a larger portfolio of lateral flow-based products.

5) Investment in R&D needs to be increased and attention needs to be paid to bridging the knowledge-innovation divide - both technological and social.

6) Ensuring local biomass supply and ecosystem services. Where bio-economic activities rely on imported resources, it is important to establish standards for assessing their environmental and social footprint.

7) Forests and agroecosystems provide much more than biomass, and often the economic importance of the age of natural and cultural heritage can surpass that of physical

value chains. These ecosystem services need to be well understood and monitored, and be an integral part of bioeconomy strategies.

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REFERENCES

1. Branzova, P. (2019). *Terminological apparatus in the field of bioeconomy.* Trakia Journal of Sciences, 17(Suppl. 1), pp. 395-399.
2. European Commission. (2018). *A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment.* 39. Luxembourg: Publications Office of the European Union.
3. Georgieva, T. (2023). *Innovation potential and innovation networks in the forest bioeconomy: the case of Bulgaria.* Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy, WoodEMA 2023 (pp. 231-235). Prague: WoodEMA.
4. Joint Research Centre. *Jobs and Wealth in the European Union Bioeconomy (Biomass producing and converting sectors)*. Retrieved 5 14, 2023, from European commission: https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html
5. Kirechev, D.; Stanimirova, M.; Ivanova, P. (2023). *Forest-based resource management in the transition to carbon neutrality in Bulgaria.* Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy (pp. 51-57). Prague: WoodEMA.
6. Kirechev, D.; Stoyanova, A.; Marinova, V. (2023). *Potential of the forest-based sector for the development of Bulgaria's bioeconomy.* Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy (pp. 58-64). Prague: WoodEMA.
7. Ministry of agriculture and food. (2023). Agricultural Report, Sofia.
8. Nováková, R.; Pauliková, A. (2023). *Agenda 2030 for sustainable development as a starting point for the environmental goals of sustainable development and bioprocessess in the wood processing industry.* Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy, WoodEMA 2023 (pp. 216-220). Prague: WoodEMA.
9. Slavova, G.; Doneva, Y. (2022). *Application of the model of circular economy between the forestry and agricultural sector.* Crisis management safety foresight inforest-based sector and SMS's operation in the global environment (pp. 383-387). Trnava: WoodEMA.
10. Turlakova, T.; Slavova, G.; Georgieva, T. (2023). *Application of regional circular economy models in the forestry sector.* Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy, WoodEMA 2023 (pp. 155–159). Prague: WoodEMA.
11. Ventsislavova Georgieva, D.; Popova-Terzyiska, R. (2023). *Modern marketing communications in the forest sector as a factor to increase the added value in terms of Covid-19.* Current Trends and Challenges for Forest-Based Sector: Carbon Neutrality and Bioeconomy, WoodEMA 2023 (pp. 69–72). Prague: WoodEMA.

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IMPACT OF FISCAL POLICY AND ECONOMIC TRENDS ON THE FORESTRY SECTOR IN BULGARIA

James Jolovski

Abstract: The paper examines the growth of forestry and connected secondary activities in the context of the economic development of Bulgaria during the period 2016-2021. The impact of the COVID-19 pandemic and the implemented fiscal measures are reviewed as well. The budget measures to counter inflation in Bulgaria in 2022 are examined additionally.
Keywords: forestry sector, GDP, fiscal policy, COVID-19, inflation

1. DEVELOPMENT OF THE FORESTRY SECTOR IN BULGARIA DURING THE PERIOD 2016-2021

During the second half of the past decade the economy of Bulgaria has been rapidly increasing with about 3-4% real GDP growth – higher than the average for the European Union, allowing convergence with the more developed countries. In 2016 the nominal GDP in current prices was almost 49 billion euro surpassing 71 billion euro in 2021 or about 46% nominal growth.

The forestry sector and connected secondary activities were expanding as well during that period – from 658 million euro in 2016 to 769 million euro in 2021. However, the rate of growth is 17% and is significantly slower compared to GDP. Thus, the share of the forestry sector decreased from 1,35% of GDP in 2016 to 1,08% of GDP in 2021.

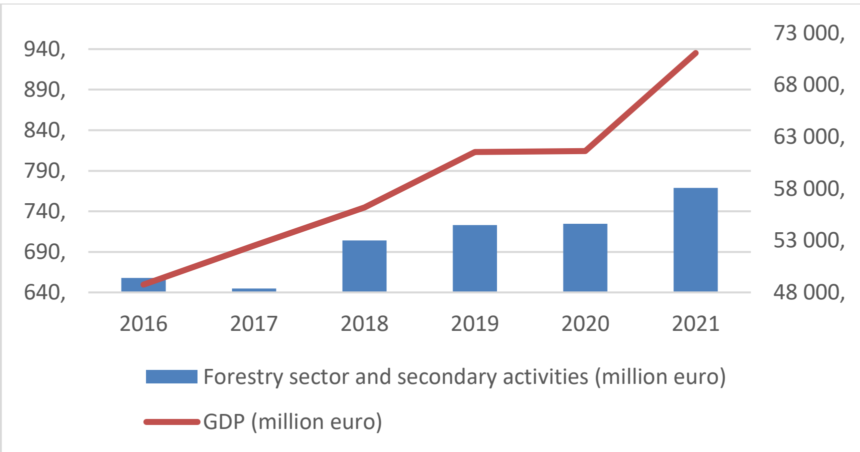

Figure 1: GDP and forestry sector growth in Bulgaria, 2016-2021, data from Eurostat

In 2017 the sector shrunk in contrast with the expanding economy which lead to a sudden drop in the share of forestry and connected secondary activities from 1,35% of GDP to 1,23%. In 2018 the opposite trend is observed – the sector was growing faster than the economy. However, in 2019 and 2021 drops of the share are registered as well.

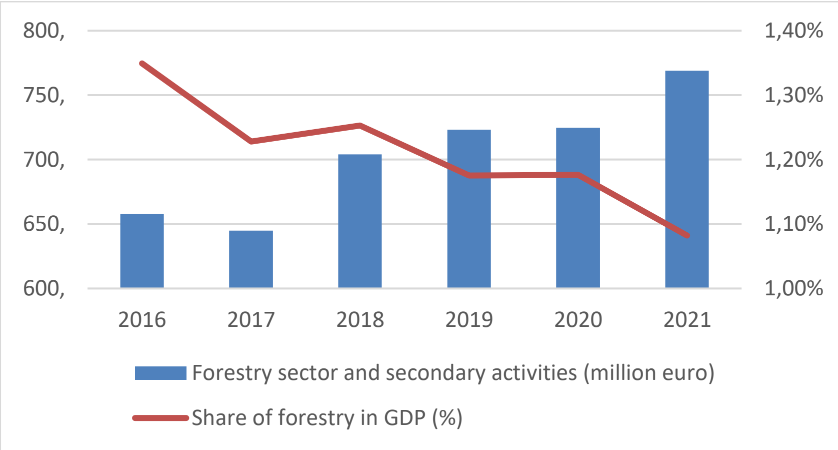

Figure 2: Share of forestry sector of GDP in Bulgaria, 2016-2021, data from Eurostat

During the pandemic of COVID-19 in 2020 the sector remained stable and kept its share unchanged. The data discussed is presented in Table 1.

Year	2016	2017	2018	2019	2020	2021
Forestry sector and secondary activities (million euro)	658	645	704	723	725	769
GDP (million euro)	48752	52502	56200	61531	61608	71060
Share of forestry in GDP (%)	1,35%	1,23%	1,25%	1,18%	1,18%	1,08%

Table 1: Economic development and forestry sector growth in Bulgaria, 2016-2021, data from Eurostat

2. COVID-19 IMPACT ON THE ECONOMY AND THE FORESTRY SECTOR OF BULGARIA

2.1. Impact of COVID-19 on the economy and fiscal policy

COVID-19 caused unexpected shock that forced most of the governments worldwide to implement measures for physical distance practically freezing whole sectors of the economy. Such restrictions were introduced in Bulgaria as well and led to a deterioration of macroeconomic indicators. Initially expected to grow with 3,3% in the 2019 autumn forecast of the Ministry of finance, the economy actually contracted with 4,2%. Although no restrictions were imposed specifically on the forestry sector and the connected secondary activities, it was negatively impacted since other key sectors were locked down.

Before the pandemic the fiscal policy of Bulgaria had been conservative rarely generating deficits and maintaining one of the lowest debt-to-GDP ratios within the members of the European union. However, the contraction of economy, caused by the restrictive measures needed to combat COVID-19, had negative impact on public revenue. The implemented fiscal measures to support the economy required funding from the state budget increasing expenditure. Thus, the simultaneous effect of these developments required a change in the course of fiscal policy. The government took advantage of the temporary escape clause and planned deficit exceeding 3% of GDP.

2.2. Fiscal measures to counter the COVID-19 pandemic

Some of the measures were targeted at specific sectors that were considered vulnerable and were affected the most. For instance, the government reduced the VAT rate from 20% to 9% for restaurants, sports facilities, books, food suitable for babies or young children and baby diapers. None of the major support policies with higher significance for the economy were targeted specifically at the forestry sector and connected secondary activities.

However, other fiscal measures provided general support that the sector could take advantage of. For instnace, some of them provided liquidity postponing public and private debt obligations. One of the main intervations was aimed at supporting employment. The programme was widely called ‘60/40’ measure because 60% of the salaries and the coresponding social security contributions were covered by the government through the state Employment agency. The programme was updated a couple of times widening the scope of the included sectors extending the support to 80% for some. Nevertheless, the forestry sector was explicitly excluded and could not take advantage of this support.

A couple of the implemented measures provided direct financial support to all the businesses that were affected. Wether the pandemic impacted a business or not is decided by using purely financial data. Thus this is one of the few programmes that forestry sector could actually take advantage of. All small enterprises that experienced decrease in their revenues of more than 20% in April 2020 compared to the registered average monthly revenue for 2019 were eligible to apply for a grant equal to 10% of their total revenue for 2019. The grant was limited in the range between BGN 3 000 and BGN 10 000, not allowing for business with annual revenue lower than BGN 30 000 to apply. While business with more than BGN 100 000 could still apply, their support was limited to BGN 10 000. Additinal similar programme targeting medium enterprises was later introduced.

In conclusion, the forestry sector and connected secondary activities were not considered vulnerable due to the COVID-19 pandemic and did not received targeted support by the governement. The data shows that the sector remained strong during 2020 and even expanded a bit but keeping its share of GDP.

3. FISCAL MEASURES TO COUNTER HIGH INFLATION

After the initial shock of the pandemic, in the second half of 2021 the inflation started rapidly increasing. There are a couple of factors that contributed to this development. For instance, it is believed that the conducted monetary policy was too expansionary leading to depreciation of the significantly increased money supply. In addition, the disrupted supply chains caused lasting shortages that continued during the accelerated demand recovery. Lastly, the war conflict between Russia and Ukraine added inflationary pressure.

The rate of inflation in Bulgaria was significantly higher than the average for the European Union. The Bulgarian National Bank was not able to actively intervene as there is a currency board in place. Rather, the expansionary policy of the European central bank is impacting the value of the Bulgarian lev due to the fixed exchange rate. However, it is believed that the main factor contributing to higher than the average European Union inflation, is that the Bulgarian economy is highly dependent on energy prices. These domestic developments impacted the forestry sector as well.

The government introduced fiscal measures that were initially communicated as anti-inflationary but later were called anti-crisis. Most of them were aimed at consumer prices instead of producer prices. With this design the measures actually encouraged consumption. However, some of them supported the business as well with individual sectors being specifically targeted – for instance the VAT rate of bread was reduced to 0%. None of the measures supported the forestry sector explicitly but it could take advantage from the excise exemption for electric energy, LPG and natural gas. The reduction of VAT for natural gas had a positive effect as well.

In conclusion, the inflation rate in Bulgaria after the pandemic was higher than the European Union average and the state introduced fiscal measures to counter the negative effects. Even though the forestry sector was affected by these developments it did not receive government support.

REFERENCES

1. Bulgarian Fiscal Council (2021): Opinion on the convergence programme of Bulgaria 2021-2023
2. Jolovski, J. (2022): *Applying fiscal measures as anti-inflationary tool in Bulgaria*. Management in businesses and the public sector. pp. 26-40
3. Metalova, D.; Jolovski, J. (2022): *Impact of the COVID-19 pandemic on the economy and the fiscal policy of Bulgaria.* Researching economic development and entrepreneurship in transition economies. pp. 65-76
4. Wunder, S.; Kaimowitz, D.; Jensen, S.; Feder, S. (2021): *Coronavirus, macroeconomy, and forests: What likely impacts?* Forest Policy and Economics, Vol. 131
5. Hlaváčková, P.; Banaś, J.; Utnik-Banaś, K. (2024): Intervention analysis of COVID-19 pandemic impact on timber price in selected markets, Forest Policy and Economics, Vol. 159

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ANALYSIS OF THE IMPACT OF COVID-19 ON THE ECONOMIC PERFORMANCE OF WOODPROCESSING ENTERPRISES IN SLOVAKIA

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Abstract: The outbreak of the COVID-19 pandemic has unleashed unprecedented challenges globally, affecting various sectors, economies, and businesses. This paper explores the profound impact of the pandemic on the economic indicators of woodprocessing enterprises in Slovakia, analyzing the intricate dynamics that have unfolded since its onset. The research investigates the effects of the pandemic period on actives, revenue streams and profitability based on data of individual companies drawn from official financial reports in database finstat. It examines the adaptability of businesses in the face of unforeseen challenges. Insights drawn from this study contribute to a deeper understanding of the vulnerabilities exposed by the pandemic, offering valuable lessons for enhancing the financial resilience of enterprises in the future.
Keywords: pandemic COVID-19, economic performance, woodprocessing enterprise

1. INTRODUCTION

The COVID-19 pandemic, declared by the World Health Organization in early 2020, has significantly affected the global economy, including the woodprocessing sector in Slovakia. This sector, pivotal to the Slovak economy due to its extensive forestry resources and contribution to exports, faced immediate and lingering challenges. The pandemic negatively affected many aspects of business e.g. in the construction sector (Gajdosikova et al., 2022), indicating potential parallels in the woodprocessing industry. Businesses experienced negative impacts on financial and economic situations, with significant impacts likely to be more pronounced in the future. This situation compelled businesses to scale back or entirely suspend their operations (Svabova et al., 2021). The reduction in production inevitably affected the added value and the management outcomes across a broad range of business entities (Belas et al., 2021). During the COVID-19 pandemic, most retail stores were closed, except for wholesale food and grocery stores, which had to comply with restrictions. These circumstances influenced consumer behavior (Taha et al., 2021) and triggered a domino effect on suppliers, affecting their sales, operations, and strategic planning. Previous studies have highlighted the vulnerabilities of global supply chains and industries to unexpected coronacrisis (Xu et al., 2020; Ivanov & Das, 2020; Zhu et al., 2020). An exploratory study in Southeast European countries, including Slovenia, Croatia, Serbia, and Bosnia and Herzegovina, indicated over 80% of respondents in the forest-products industry reported negative changes due to the pandemic. Challenges included increased material prices, transportation costs, and supply chain disruptions (Kuzman et al., 2022). Researchers (Chen & Yang, 2021) have examined the situation through the lens of accounting data, revealing that the COVID-19 pandemic has led to a decrease in consumer preference for wooden furniture in China but less pronounced for wooden furniture made by extra large manufacturers.

However, there is a gap in literature specifically addressing the woodprocessing industry in Slovakia during the COVID-19 pandemic. This study seeks to uncover the extent of the pandemic's impact on the economic performance of Slovak woodprocessing enterprises. For the woodprocessing industry, lessons from related sectors suggest the importance of adaptability, diversification, and the potential for state support to mitigate adverse effects. It offers valuable insights for policymakers, industry stakeholders, and researchers interested in the economic implications of global crises on the woodprocessing industry.

2. METHODOLOGY

In conducting a comprehensive review of the existing literature, were systematically searched papers related to the economic impact of pandemics on industries, especially on the woodworking. Selection criteria included scientific papers published between 2019 and 2023, ensuring the relevance and currency of the research findings. Data regarding financial metrics and operational statistics of companies within the forest-wood products industry were obtained from Finstat database. We focused on the woodprocessing industry (SK NACE 16, 17, and 31). The dataset spanned from 2017 to 2021, focusing on annual revenue, EBITDA, profit/loss, asset valuations, and inventory levels. This timeframe was chosen to capture both pre-pandemic performance and the impact of COVID-19. To show the performance results, the financial indicators per unit were used. Inflation is crucial when analyzing financial performance over time, it is distorting nominal growth figures. To account for this, the real value of the financial data was calculated, taking into account the inflation rate developments from 2017 to 2021 (1.3%, 2.5%, 2.7%, 3.23%, 4.43%).

3. RESULTS

The initial findings suggest a disruption in the revenue streams per unit (p.u.) of woodprocessing enterprises during the second half of 2019 and first half of 2020, coinciding with the onset of the pandemic and the implementation of restrictive measures. However, the data also indicate a varied degree of resilience and adaptability among enterprises, with some managing to recover and even improve their profitability towards the end of 2020 and into 2021.

The results of woodprocessing sectors are presented in tables 1-3. Legend for the Tables:

SRR – Sum of real revenue *RRu* – Real revenue/unit *Eu* – Real EBITDA/unit
RPu – Real profit/ unit *RAu* – Real Assets/unit *RIu* – Real Inventories/unit

3.1. Financial data of SK NACE 16

The SK NACE 16 sector experienced significant challenges due to the COVID-19 pandemic, particularly evident in the sharp drop in real revenue p.u. in 2020. However, the sector's resilience is underscored by its recovery in 2021, likely aided by strategic adaptations and an evolving market landscape. The positive trends in real EBITDA and profit/loss p.u., despite the pandemic, reflect effective management and operational efficiency. The decline in real assets p.u. suggests asset optimization, while inventory management practices appear to have been adjusted in response to the pandemic's challenges. Overall, the sector's ability to navigate through the pandemic and initiate a recovery by 2021 highlights its adaptive capacity and resilience amidst unprecedented global challenges.

Table 1. SK NACE 16: financial data

	2017	2018	2019	2020	2021
SRR	901.482	1000.637	971.404	936.924	1258.279
RRu	0.655	0.652	0.578	0.507	0.630
REu	0.013	0.035	0.045	0.045	0.050
RPu	0.018	0.020	0.014	0.018	0.040
RAu	0.318	0.301	0.282	0.256	0.252
RIu	0.080	0.077	0.074	0.061	0.076

Source: own calculation according to data from Finstat

Real Revenue per unit declined from 2017, a more significant drop in 2019 suggests the beginning of challenges even before the pandemic, possibly due to market saturation, increased competition, or other sector-specific issues. A sharp decline to 0.507 in 2020 highlights the immediate adverse effect of the pandemic, likely due to lockdowns, reduced consumer spending, and disruptions in supply chains. A rebound in real revenue p.u. to 0.630 in 2021 suggests recovery and possibly adaptation to new market conditions and consumer behaviors, reflecting resilience within the sector.

Real EBITDA per unit gradual increased and indicate improving operational efficiency and profitability on a per-unit basis. The maintenance of this positive trajectory through 2020 and an increase in 2021 imply effective cost management and possibly operational adaptations during the pandemic.

Real Profit/Loss per unit: the continued profitability through the pandemic, with a notable increase in 2021, underscores effective strategic management and possibly an increased demand for products or services within this sector.

Real Assets per unit: the gradual decline in real assets p.u. over the period might reflect asset optimization strategies, divestment of non-core assets, or a shift towards a more asset-light operational model. The accelerated decrease during the pandemic could indicate intensified efforts to reduce costs or the need to liquidate assets for liquidity.

Real Inventories per unit: the significant drop in 2020 followed by a rebound in 2021 could reflect initial supply chain disruptions due to the pandemic, followed by a recalibration of inventory levels in response to shifting demand patterns.

3.2. Financial data of SK NACE 17

The SK NACE 17 sector experienced a significant downturn in 2020 due to the COVID-19 pandemic, particularly in terms of revenue and profitability. The slight recovery in 2021 across most metrics suggests the beginning of a rebound. However, the limited recovery in profitability indicates that the sector may still be grappling with the pandemic's lingering effects and adjusting to the new normal. The increase in assets suggests continued investment in the sector, which could be positive for long-term growth. The inventory levels in 2021 might reflect optimism about future demand or could signify challenges in aligning production with market demand. Overall, while the sector is showing signs of recovery, it has not yet fully rebounded to pre-pandemic performance levels.

Table 2. SK NACE 17: financial data

	2017	2018	2019	2020	2021
SRR	1009.4	1078.27	1132.66	1052.04	920.52
RRu	6.961	6.697	6.663	5.877	5.030
REu	0.921	1.106	1.217	0.937	0.523
RPu	0.414	0.715	0.824	0.536	0.204
RAu	4.570	4.790	4.821	5.488	5.812
RIu	0.614	0.551	0.646	0.675	0.614

Source: own calculation according to data from Finstat

Real Revenue per unit: a significant drop in real revenue in 2020 and 2021 indicates the substantial adverse effect of the pandemic on sales, likely due to decreased demand, operational restrictions, or supply chain disruptions.

Real EBITDA per unit: upward trend in EBITDA before pandemic shows improving operational efficiency and profitability. A sharp decline in EBITDA highlights the impact of the pandemic on operational profitability, reflecting increased costs, reduced margins, or both.

Real Profit/Loss per unit: consistent growth up to 2019 suggests increasing profitability and effective cost management. A drastic reduction to 0.204 in 2021 demonstrates the severe impact of the pandemic on the bottom line.

Real Assets per unit: an increasing trend over the period indicates investment in the sector, possibly in expansion or modernization. The continued increase through the pandemic years suggests ongoing investment, perhaps towards adapting operations for new market conditions or leveraging technology for efficiency.

Real Inventories per unit: fluctuations in inventories p.u., with no clear trend, suggest changes in production strategy, sales forecasting accuracy and supply chain management. An increase above pre-pandemic levels could indicate anticipation of market recovery, improved demand forecasting, or potentially issues with inventory turnover.

3.3. Financial data of SK NACE 31

The COVID-19 pandemic had a significant, albeit nuanced, impact on SK NACE 31 enterprises. While real revenue initially suffered, the increase in EBITDA and profit during the pandemic highlights effective management strategies to counteract operational and market challenges. The fluctuation in assets and inventories suggests adaptive strategies in asset management and supply chain operations. The rebound in several metrics by 2021 indicates a sector on the path to recovery, though still navigating the complexities of a post-pandemic economic landscape.

Real Revenue per unit: there was an increase up to 2018, indicating growth and possibly expanding market demand but then showing a downward trend from 2019. A noticeable drop in 2020 signifies the direct impact of the pandemic, likely due to reduced consumer spending, supply chain disruptions, or operational restrictions. A rebound in real revenue close to 2019 levels suggests recovery, adapting to the new market conditions, or benefiting from pent-up demand.

Real EBITDA per unit: an increase in real EBITDA p.u. during the pandemic years, contrary to the revenue drop, could imply effective cost management or operational adjustments to maintain profitability under challenging conditions. A slight decrease in 2021 but still higher than in pre-pandemic years suggests sustained operational efficiency but perhaps facing new challenges as the market continues to adapt post-pandemic.

Table 3. SK NACE 31: financial data

	2017	2018	2019	2020	2021
SRR	856.291	879.658	828.945	755.979	822.965
RRu	1.920	1.929	1.798	1.651	1.797
REu	0.076	0.059	0.034	0.092	0.078
RPu	0.005	-0.015	-0.036	0.018	0.030
RAu	0.678	0.680	0.591	0.565	0.586
RIu	0.314	0.313	0.310	0.258	0.320

Source: own calculation according to data from Finstat

Real Profit/Loss per unit: the variability in profit/loss shows financial instability in certain years. The shift to a profit in 2020 is remarkable, reflecting possibly lower operational costs, government support measures, or a shift in business strategy in response to the pandemic. Continued profitability, improving from 2020, indicates effective adaptation and potential market recovery.

Real Assets per unit: a decrease may reflect asset sell-offs, depreciation, or a strategic reduction in capital expenditures during the pandemic. A slight increase in assets suggests cautious reinvestment or asset accumulation in anticipation of growth or as a response to operational needs.

Real Inventories per unit: the decrease reflects likely adjustments to lower demand or disruptions in supply chains. A bounce back in inventories in 2021 above pre-pandemic levels might signify optimism about future demand or improvements in production capacity.

4. DISCUSSION AND CONCLUSION

The pandemic significantly dampened macroeconomic landscape. However, this impact, while broad, was short-lived. With effective control measures against the pandemic, the initial quarter's economic fluctuations are unlikely to alter the long-term positive trajectory of the global economy (Shen et al., 2020). Survey findings of Kuzman et al. (2022) reveal that while the COVID-19 pandemic has affected the forest-wood products industry, certain segments have experienced beneficial impacts. The Slovak woodprocessing industry faced significant operational and financial challenges due to the COVID-19 pandemic, with all sectors experiencing a downturn in 2020. However, the industry's recovery in 2021 across key financial metrics suggests resilience and adaptability. The impact of COVID-19 on woodprocessing enterprises in Slovakia underscores the critical importance of adaptability and financial resilience in the face of global crises. The woodworking industry, with its varied segments under SK NACE codes 16, 17, and 31, demonstrates both the vulnerabilities and strengths inherent in diverse operational models and market dependencies. The analysis reveals that companies with diversified supply chains, digitalization of sales and operations, and flexible business models were better equipped to navigate the challenges posed by the pandemic. However, it also presented opportunities for innovation and adaptation. The lessons learned from this period should guide enterprises towards building more resilient business models, capable of withstanding future global disruptions.

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REFERENCES

1. Belas, J.; Gavurova, B.; Dvorsky, J.; Cepel, M.; Durana, P. (2021): *The impact of the COVID-19 pandemic on selected areas of a management system in SMEs*. In: Econ. Res. Ekon. Istraz. 35, 3754–3777.
2. Gajdosikova, D., Valaskova, K., Kliestik, T., & Machová, V. (2022): *COVID-19 Pandemic and Its Impact on Challenges in the Construction Sector: A Case Study of Slovak Enterprises*. In: *Mathematics*. https://doi.org/10.3390/math10173130.
3. Chen, J., & Yang, C. (2021): *The Impact of the COVID-19 Pandemic on Consumers' Preferences for Wood Furniture: An Accounting Perspective*. In: *Forests*. https://doi.org/10.3390/f12121637.
4. Ivanov, D., & Das, A. (2020): *Coronavirus (COVID-19/SARS-CoV-2) and supply chain resilience: a research note*. In: *International Journal of Integrated Supply Management*, 13, 90-102. https://doi.org/10.1504/ijism.2020.107780.
5. Kuzman, M., Oblak, L., Glavonjić, B., Barčić, A., Obućina, M., Haviarova, E., & Grošelj, P. (2022): *Impact of COVID-19 on wood-based products industry: An exploratory study in Slovenia, Croatia, Serbia, and BiH*. In: *Wood Material Science & Engineering*, 18, 1115 - 1126. https://doi.org/10.1080/17480272.2022.2109210.
6. Shen, H., Fu, M., Pan, H., Yu, Z., & Chen, Y. (2020): *The Impact of the COVID-19 Pandemic on Firm Performance.* In: *Emerging Markets Finance and Trade*, 56, 2213 - 2230. https://doi.org/10.1080/1540496X.2020.1785863.
7. Svabova, L.; Tesarova, E.N.; Durica, M.; Strakova, L. (2021): *Evaluation of the impacts of the COVID-19 pandemic on the development of the unemployment rate in Slovakia: Counterfactual before-after comparison*. In: Equilib. Q. J. Econ. Econ. Policy, 16, 261–284.
8. Taha, V., Pencarelli, T., Škerháková, V., Fedorko, R., & Košíková, M. (2021): *The Use of Social Media and Its Impact on Shopping Behavior of Slovak and Italian Consumers during COVID-19 Pandemic.* In: *Sustainability*. https://doi.org/10.3390/SU13041710
9. Xu, Z., Elomri, A., Kerbache, L., & Omri, A. (2020): *Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives.* In: IEEE Engineering Management Review, 48, 153-166. https://doi.org/10.1109/EMR.2020.3018420.
10. Zhu, G., Chou, M., & Tsai, C. (2020): *Lessons Learned from the COVID-19 Pandemic Exposing the Shortcomings of Current Supply Chain Operations: A Long-Term Prescriptive Offering.* In: *Sustainability*. https://doi.org/10.3390/su12145858.
11. www.finstat.sk

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FOSTERING SUSTAINABLE DEVELOPMENT: AN IN-DEPTH EXAMINATION OF POLICIES AND STRATEGIES FOR PRESERVING NESSEBAR'S CULTURAL HERITAGE, EMPHASIZING TRADITIONAL CRAFTS AND WOODEN HOUSES

Sonia Mileva, Milena Krachanova, Aglika Ikonomova

Abstract: The Ancient city of Nessebar, designated as a UNESCO World Heritage Site, boasts a distinctive array of wooden houses predominantly constructed during the 19th century. Emblematic of the Black Sea architecture of that period, these houses serve as tangible representations of the various phases in the evolution of residential vernacular architecture. However, recent years have witnessed a concerning trend—the erosion of intangible cultural heritage and traditional practices, particularly evident in the fading traditional construction methods and wood crafts. This deterioration poses a threat to the overall conservation status of these historical monuments.

This paper undertakes a historical exploration to elucidate the factors contributing to the present condition of the wooden houses in Nessebar. Moreover, it critically analyses both national and local policies aimed at preserving the tangible and intangible heritage associated with these structures. A pivotal aspect is the emphasis on sustainable measures imperative for revitalizing traditional construction practices and wood crafts, thereby safeguarding the cultural legacy encapsulated in these monuments.

The study underscores the imperative for holistic measures, encompassing the conservation of existing wooden structures, rejuvenation of traditional crafts, techniques, and materials, and the restoration of a symbiotic relationship between the local community and its cultural heritage. These endeavors stand as a crucial guarantee fostering sustainable development and preservation of the unique cultural heritage of Nessebar and its Outstanding Universal Value (OUV).
Keywords: wooden houses, Nessebar, World heritage, sustainability, cultural heritage policy

1. INTRODUCTION

The Ancient City of Nessebar is a historic city in Southeastern Bulgaria, inscribed on the UNESCO World Heritage List in 1983. Situated on a Black Sea rocky peninsula the city is known for its remarkable medieval churches, archaeology (incl. underwater) and the Renaissance houses, which are part of the attributes conveying the Outstanding Universal value (OUV) of the property.

The emergence of these houses is associated with the 18th century economic revival of Nessebar which seriously reflects on the residential buildings (Centre for Cultural Heritage and Architecture, 2023). Most of the houses are built in the 19th century and are "*typical of the Black Sea architecture of the period*" (UNESCO, 2010). Since the beginning of the 20th century, ninety Renaissance houses in Nessebar have been officially recognized as cultural heritage properties under national legislation. Among them, three houses hold the prestigious status of national heritage. These renaissance residential buildings are distributed unevenly throughout the peninsula, as standalone samples or as picturesque street ensembles.

2. NESSEBAR WOODEN HOUSES

The Bulgarian Renaissance house, particularly on the Black Sea coast, exemplified by Nessebar, embraced a "wooden house" style. This shift from stone house, as noted by Mavrodinov (1947), occurred primarily in the upper living areas. Wood offered advantages in construction speed, ease of processing, and thermal insulation, making it ideal for these floors. Additionally, timber's seismic resistance and the ability to create decorative elements with various colors and textures further contributed to its popularity. Stamov (2007) clarifies the **"wooden house" concept**, specifying that only the upper living floors are built entirely of wood. Therefore, the broader understanding for the "Bulgarian Renaissance house" refers to a mixed-construction dwelling: a stone ground floor for non-residential purposes topped by one or two wooden stories for living quarters. Zlatev (1955), Vakarelski (1974), Angelova (1975) consider that the Black Sea house fully meets the understanding of a wooden house as it is stone/mud-built houses with wooden cladding. Ivanchev (1957) characterizes these structures as "wooden houses with stone ground floor", echoing the architectural style of the earliest buildings from the era of the First Bulgarian Kingdom, standing as a distinctive example within the broader category of Black Sea Houses, with its unique attributes.

These houses are shaped by the distinct climatic conditions of the region. Marked by robust autumn and winter winds, perpetual high humidity, and significant summer temperature fluctuations, they evolved into a closed-type design, ensuring optimal living comfort as noted by Jordanova-Petrova (2020). Nessebar's houses typically comprise two floors, although more elaborate examples, such as Eulambius's, Bogotov's, and Vardaliev's houses, feature a third floor, also constructed of wood. The use of local materials plays an important role in shaping the urban landscape of the Ancient City of Nessebar. The extensive use of stone from the cliffs and shores and wood from the nearby forests, while most of the timber came from the wooded slopes of Strandzha (Ivanchev, 1957).

The wood in the Nessebar house fulfils different functions: structural, utilitarian and decorative. (1) The structural function is expressed in form of a timber and plaster skeleton of wooden beams, placed vertically and diagonally for the external and internal walls, the floor construction with the bay elevation and the roof as well as the timber façade cladding, covered with light timber frame; (2) Utilitarian functions are associated with doors (exterior and interior), windows, built-ins and fireplaces in rooms as well as the interior furniture such as: minders, chairs and tables; (3) Decorative functions are in terms of artistic elements in the exterior (facade pilasters with base and capitals, decoration of bays and eaves with character elements) and in the interior (ornamented ceilings).

Most distinctive element testifying for the two different construction periods is the cladding of the facade wall. (1) The older construction and facade cladding is used until the 18th century at the latest. Thin oak planks (6-8 cm in height) are placed in horizontal direction partially overlapping at the top each other; (2) The 19th century façade cladding introduces coniferous material – cham (12-24 cm in hight), because it more resistant to weather changes (drought and moisture) and cheaper. These two types of panelling were used to finish the exterior of the facade wall.

3. CHALLENGES AND THREATS TO WOODEN HOUSES

The Renaissance residential architecture is one of the main attributes coveying the OUV and defining the appearance of the Ancient City of Nessebar. Currently their degree of authenticity is not high (NIICH, 2018). **Regarding the wooden elements a deviation from the characteristic scale of the façade claddings is observed as well as a strong simplification of the detail. There is a partial replacement of wooden windows and doors with PVC and lack of window and corner frames.**

The World heritage city was suggested by ICOMOS and WHC for possible inscription on the List of World Heritage in Danger. The Reactive monitoring reports on the "Ancient City of Nessebar" (2018, 2023) recommend efficient measures to encourage and support private owners of buildings in the process of maintenance and conservation/restoration of their buildings. Nessebar's houses serve as tangible representations of the intangible cultural heritage on the peninsula as well as traditional building practices.

The primary concern regarding the wooden houses lies in the erosion of intangible cultural heritage and traditional practices, notably evidenced by the diminishing traditional construction methods and wood crafts. This deterioration poses a significant threat to the overall conservation status of these historical monuments, presenting challenges in their preservation and restoration efforts. Traditional building crafts used to play a crucial role in the construction and maintenance of wooden houses, as they embody centuries-old techniques, knowledge, and cultural practices specific to the region. These crafts encompassed various aspects, including timber framing, joinery, carving, and ornamentation, each contributing to the unique character and identity of the structures. The builders/ craftsmen used to came from different regions in Bulgaria (Triavna, Malko Tarnovo, Trevno, Dryanovo, Gabrovo), Macedonia (Lerin, Kostur, Debar and elsewhere), and even Asia Minor Christians - Bulgarians, called Kara - Manlii. The master builders knew very well the qualities and workmanship of the materials they used. They used the winter season to harvest timber because the tree "sleeps", the sap has gone down and after felling it is denser, less "shrinking" and less attacked by pests.

The process of loss of the wood traditional practices is long, complex and attributed to various aspects. From one side the modernization and advent of modern building materials and construction methods started to replace the traditional ones. The most important local material – *the wood started to become more scarce*. This process began even before the Bulgarian liberation and the decline of the Ottoman Empire, when extensive forests were burned so that the outlaws would not hide; other parts of the forests were ruthlessly exploited to satisfy the timber-poor South (Ivanchev, 1957).

The alteration in cultural dynamics and the mass exodus from Nessebar in 1925, where most of the local families departed, marked a pivotal moment deepening this transformation. This migration was largely prompted by the decisive Convention for Exchange of Minorities between Bulgaria and Greece in 1919. As a result, a big number of refugees from Macedonia, Thrace and Dobrudzha resettled in Nessebar, inhabiting the newly constructed "Sharon Houses," named after their architect (Theoklieva-Stoycheva, 2019). These newly erected dwellings diverged markedly from the Renaissance-style houses in terms of volume, material, and detailing. They were predominantly single-storey field houses featuring plaster facades, devoid of wooden cladding and ornate embellishments. Notably, many of these structures were built on the sites of partially demolished Renaissance houses. These processes mark the end of the construction of the Renaissance wooden houses in Nessebar and are the main reasons for loss of the traditional building practices.

4. POLICIES AND STRATEGIES FOR PRESEVING THE NESSEBAR'S HERITAGE AND WOODEN HOUSES

During the 1960s to the 1980s, concerted efforts were undertaken by the National Institute of Monuments of Culture (now National Institute of Immovable Cultural Heritage) to preserve the Nessebar's houses. The Ancient city was officially designated as an architectural reserve in 1956, and subsequently inscribed on the UNESCO World Heritage List in 1983. However, following the political changes after 1989s, the state's withdrawal from its role as the primary funder and driving force for the preservation of Nessebar's OUV, particularly its wooden houses, became evident.

The growth of Tourism influenced the urban landscape of the city. The wooden houses started to experience modifications of authenticity to accommodate modern advancements and satisfying the changing needs of house owners. Policy and legislative initiatives primarily prioritized the tangible cultural heritage, as world heritage city, neglecting of the intangible heritage associated with traditional wood crafts and building methods. Problems rised with illegal construction and atypical interventions on houses, including additional floors. The UNESCO designation and the necessity to reconcile legal frameworks, conservation policies, and associated obligations among Renaissance house owners created tension and were perceived as constraints on "development" by the local community (Luleva, 2014).

The UNESCO 2023 monitoring report confirmed that the state of the Ancient City of Nessebar states a continued lack of appropriate legal, planning, monitoring, management and conservation mechanisms, alerting that most of the wooden houses that testify for the architectural mastery of the Balkans and the Eastern Mediterranean region have been irreversibly altered or converted. The National Institute for Immovable Cultural Heritage (NIICH) has been diligently documenting the attributes that convey the Outstanding Universal Value (OUV) of the wooden houses, providing facade plans and silhouettes, and in 2023 a 3D model and digital map. All of this is invaluable to archaeologists, architects, restorers, engineers, historians, traditional wood crafts building materials specialists engaged to preserve the authenticity and the OUV.

At local level, the Municipality of Nessebar adopted the "Program for Sustainable Development of Tourism in the Municipality of Nessebar 2018-2024," along with a Tourism Development Program integrated within the Plan for Integrated Development of the Municipality of Nessebar for the period 2021–2027. These decisions reflect the municipality's commitment to foster sustainable tourism practices and promoting balanced development within the region. A Cultural Heritage Strategy for the period 2023-2032 has been developed that acknowledges Nessebar's heritage as a distinctive demonstration of the synergy between tangible elements (both movable and immovable, including underwater artefacts) and intangible cultural heritage, complemented by its abundant natural heritage. The Strategy outlines plans to allocate financial and technical resources for the restoration and rehabilitation of buildings of national and local significance. It also proposes the implementation of effective measures to incentivize and assist private owners in maintaining, conserving, and restoring their properties. The municipality intends to launch local program to support private owners, with the aim of preserving and revitalizing houses while restoring the authentic architectural landscape of the Ancient city.

5. TRADITIONAL WOODWORKING CRAFTS

Despite of the presence of the 2001 Skilled Crafts Act (SCA) the loss of crafts continues. From the comprehensive list of 129 trades included in SCA, 72 have been removed in 2011. Regarding traditional crafts associated with woodworking, only woodcarving and crafting wooden utensils (whittling) as distinct crafts are recognized.

The situational analysis in the education field reveals that at the national level, only two specialized secondary schools – the National High School of Applied Arts “Trevnenska school and the National School for Applied Arts “St. Luke” in Sofia – educate students in the profession of "artist - applied arts," with speciality "Decorative Woodcarving". The number of secondary school graduates with skills in wood processing is very low (yearly between 12-19 in total). According to the data from Reginal and National Chambers, for the period 2019-2023 the graduated with Master (13) and Journeyman (15) are in total 28. Based on education and training data, it is evident that there is an exceedingly low number of graduates in traditional woodworking crafts at the national level. This turns as a significant challenge and makes it increasingly difficult to find skilled with traditional wood building practices builders, needed for preservation of the unique characteristics of wooden houses, as in Nessebar.

6. FOSTERING SUSTAINABLE DEVELOPMENT

The conservation of existing wooden structures, rejuvenation of traditional crafts, techniques, and materials, and the restoration of a symbiotic relationship between the local community and its cultural heritage are crucial for fostering sustainable development and preservation of the unique cultural heritage of Nessebar and its OUV. The community based approach related to both crafts as traditional practices in wooden houses construction, and preservation of the houses as tangible heritage will assure and foster the sustainable development. The Nessebar's Cultural Heritage Strategy forsees not only finanicial support, but also creation of programs that educate and raise awareness, especially amongst the younger members of society, cultivating a deeper understanding and respect for this heritage. The strategy intorduces into existing municipal mechanisms and tools, including the integrated conservation and management, the participatory governance and the people-centred approach. The provision of support to the bearers of traditional knowledge and skills is also foreseen, including creation of opportunities for targeted funding.

CONCLUSION

Wooden houses are a cornerstone of Nessebar's historic landscape, significantly contributing to its OUV as recognized by UNESCO. The preservation of their authentical appearance remains to be achieved (UNESCO, 2023). However, Nessebar's status as a living city, coupled with tourism growth and the desire for improved living standards, has led to the introduction of modern, sophisticated building materials. This trend threatens the authenticity of the wooden houses and puts in danger the WH city. All attempt to find a mechanism to support the house owners, to change and recover the original architectural landscape is challenged by the losses of traditional woodworking crafts. Fluctuations in the political and economic landscape significantly impacted the crafts and craftsmanship by altering regulations, the recognition of training programs, and the societal perception of their importance for cultural heritage and wooden work crafts in particular (Kabakov et al., 2016). Sustainability of Nessebar's cultural heritage and its wooden houses can only be achieved though integrated measures combining financial support, inclusion of local community and rebuilding traditional knowledge and skills.

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REFERENCES

1. Angelova, R. (1975): *Renaissance Folk Architecture in the Eastern Old Mountains* [In Bulgarian], *The Architecture of the Bulgarian Revival*, Sofia: Bulgarian Academy of Sciences.
2. Centre for Cultural Heritage and Architecture. (2023): *Cultural Heritage Strategy of Nessebar Municipality for the period 2023-2032.*
3. Ivanchev, I. (1957): *Nessebar and its houses [In Bulgarian].* Sofia: Nauka i Izksutvo.
4. Jordanova-Petrova, M. (2020): *Residential Architecture in Bulgaria 17-18 century [In Bulgarian].* Sofia: New Bulgarian University Publishing House.
5. Kabakov I.; Vasilev D.; Nikolaeva M.; Popova M.; Zvancahrova M.; Krasteva M. . (2016): *Harnessing the Cultural Potential of Traditional Arts and Crafts.* The Fabric Association, Gabrovo.
6. Luleva, A. (2014): The Ancient city of Nessebar between the Outstanding universal value and the Tourist Indsutry. An Ethographic study of a conflict . *Anthropology , 1*.
7. Mavrodinov, N. (1947): *Bulgarian Wooden Architecture* (In Bulgarian). Sofia.
8. NIICH. (2018): *Monitoring report of the state of sites with the status of immovable CH property on the territory of the "Ancient City of Nessebar".* Sofia: National Institute of Immovable Cultural Heritage (NIICH).
9. Stamov, S. (2007): *The wooden folk house [In Bulgarian].* Sofia: second edition.
10. Theoklieva-Stoycheva, E. (2019): *The golden book of Nessebar.* Burgas: Informa Print.
11. Vakarelski, H. (1974): *Etnography of Bulgaria [In Bulgarian].* Sofia: ArtGraph.
12. Zlatev, T. (1955): *The Bulgarian House during the Renaissance.* Sofia : Nauka i Izkustvo.
13. ***UNESCO. (2010). *Retrospective Statement of OUV.* URL: https://whc.unesco.org/en/list/217
14. ***UNESCO. (2023). *State of Conservation Ancient City of Nessebar*. URL: https://whc.unesco.org/en/soc/4439

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AGROFORESTRY - AN OPPORTUNITY FOR THE DEVELOPMENT OF RURAL TERRITORIES IN BULGARIA

Damyan Kirechev

Abstract: Agroforestry is a current land-use technique that combines woody plants with crop production and livestock rearing. Agroforestry provides significant potential for the development of carbon farming. It can play an important role in reducing greenhouse gases and thus influence climate change. The importance of agroforestry practices is great in increasing the sustainability of agriculture. The report explores innovative agroforestry practices that have the potential to be developed in Bulgaria and can improve rural development. Agroforestry can contribute to increasing rural sustainability through the use of tree-based products, improving supply chains, providing population benefits, etc. The conditions are created for improving local economies and increasing sustainability in their development. Opportunities for financing agroforestry practices on farms in Bulgaria through the Common Agricultural Policy are explored.
Keywords: agroforestry, agroforestry systems, benefits of agroforestry, agroforestry policy.

1. AGROFORESTRY IN CONTEMPORARY LAND USE

Agroforestry is a multifunctional and environmentally friendly modern system in the use of land in agricultural production systems that provides a variety of benefits to society - environmental, economic and social. Agroforestry can contribute to a wide range of Sustainable Development Goals (SDGs) (FAO and ICRAF, 2019), by helping to sustain livelihoods, reduce poverty in rural areas, support access to cleaner energy, sustain soils and lands, and combat climate change. Agroforestry provides opportunities, but also faces a number of challenges, such as the need for policy and legal incentives, improving coordination between the forestry and agroforestry sectors, introducing innovations and raising the awareness of agroforestry actors. The aim of this publication is aimed at revealing the current understanding of agroforestry systems and the benefits for rural development. After an analysis of the state of agroforestry practices in the world, the European Union and Bulgaria, to point out the opportunities for the development of agroforestry in Bulgaria and the possibilities for public support of solutions in this field.

1.1. An understanding of agroforestry

Agroforestry can be seen as a relatively new name for old practices (Nair, 1993). The definition of agroforestry highlights two main characteristics: 1) the deliberate cultivation of woody species simultaneously with agricultural species; 2) the presence of interactions between woody and non-woody components in the system (ecological, economic and social). Discussions on understanding agroecology have been summarized by the World Agroforestry Centre (SIFOR-ICRAF, n.d.), which defines agroforestry as "a generic term for land-use systems and practices in which woody perennials (trees, shrubs, etc.) are deliberately integrated with crops and/or livestock in the same land management unit in some form of spatial arrangement or temporal sequence." This definition has gained wider acceptance over time. Agroforestry is currently seen as a multifunctional land use agroecosystem involving the cultivation of tree species with crops or livestock. With agroforestry, land is used holistically and synergistically by different stakeholders, including farmers, livestock and plants (Ramil Brick, Holland, Anagnostou, Brown,, & Desmulliez, 2022). By integrating crop/livestock production and tree cultivation, this practice has the potential to diversify and increase farmers' production by providing food, wood, fibre and medicines, while providing environmental and social benefits such as e.g. soil fertility, erosion control, water regulation, carbon sequestration, biodiversity and resilience to natural hazards (Rigueiro-Rodróguez, McAdam, & Mosquera-Losada, 2009), (Nair & Garrity, 2012), (Mosquera-Losada, et al., 2012), (Nair, Kumar, & Nair, 2021), (Jatav, Rajput, Minkina, Van Hullebusch, & Dutta, 2024). Discussing the understanding of agroforestry, there are three intrinsic characteristics that allow its evaluation (Nair P. , 1993): 1) Productivity; 2) Environmental sustainability; 3) Adoption of agroforestry practices by the farming community according to local conditions.

The concept of agroforestry stems from the expected role of on- and off-farm tree production in supporting sustainable land use and natural resource management. This concept is based on the premise that land-use systems that are structurally and functionally more complex than crops or tree monocultures lead to greater efficiency of resource capture and use (nutrients, light, water) and greater structural diversity, resulting in tighter nutrient cycles (Nair, Gordon, & Mosquera-Losada, 2008). While aboveground and belowground diversity provides more stability and resilience to the system at the site level, systems provide connectivity to forests and other landscape or watershed features.

1.2. Types of agroforestry systems

In the systematics of agroforestry, there are broadly three types of agroforestry (Nair P. , 1993), (Sharma, et al., 2016): 1), agroforestry that integrates annual crops and trees; 2) agroforestry that defines the integration of livestock and trees; 3) agroforestry that integrates annual crops, livestock and trees. In addition, there are different forms of agroforestry systems, such as alley cropping systems, intercropping or hedgerow systems.

Understanding agroforestry systems in Europe and identifying viable practices from the agroforestry system, the AGFORWARD project was implemented in the European Union between 2014 and 2017 (AGroFORestry that Will Advance Rural Development) (AGFORWARD (AGroFORestry that Will Advance Rural Development), n.d.). In its final report, the project evaluated innovative agroforestry designs and practices for places where agroforestry is currently not practiced or declining (Burgess, et al., 2018). AGFORWARD project results focus on four types of agroforestry systems (Burgess & Rosati, 2018), later adopted in European policy: agroforestry systems of high natural and cultural value; integration of grazing or intercropping in high-value tree systems; including fruit trees grown for high-quality timber; integration of trees into arable systems; integration of trees into livestock systems

Further studies from 2018 have identified key spatial agroforestry practices suitable for temperate areas: silvopastoral, silvoarable, forest farming, hedgerows, windbreaks and riparian buffer strips, as well as home gardens/kitchen gardens (Mosquera-Losada, et al., 2018), (Augère-Granier, 2020): Silvopasture - a combination of trees or shrubs for forage; Silvoarable systems - based on woody vegetation planted with annual or perennial crops (alley crops); Forest farming systems - wooded areas used to harvest crops for medicinal, ornamental or other purposes; Home gardens - combining trees or shrubs with vegetable gardens in areas alongside settlements. Combined options for growing trees and shrubs together with livestock can also be implemented in the agroforestry system, such as: Windbreaks and riparian buffers of trees or shrubs that act as a shelter buffer; Rows of trees and shrubs in grazing areas.

The development of agroforestry as a sustainable farming system to increase agricultural productivity and profitability is a subject of deep interest in EU countries. But the short-term transition from specialised crop and livestock systems to agroforestry can be challenging. The 2016-2017 EIP-AGRI Agroforestry Focus Group (EIP-AGRI, 2017) brought together experts from across Europe to explore existing practices, list challenges and opportunities, and discuss ways to further develop economically viable, sustainable agroforestry systems in Europe.

In Bulgaria, the most common types of agroforestry are forest-pastoral, shelter belt and alley cropping. Although the conditions in the country are favourable (areas with agricultural use are 5.2 million ha - about 47% of the country's territory, including 68.9% arable land, 0.3% family gardens, 3% perennial crops, and permanent grassland is 27.8%; forest areas and protected forests are 38.3% of the country's territory), socio-economic incentives and lower environmental needs, it is not very familiar to stakeholders as theory and practice. There are agroforestry practices, but there is a lack of a comprehensive concept of agroforestry development (Kachova, V.; Hinkov, G.; Popov, E.; Trichkov, L.; Mosquera-Losada, R., 2016). The Agroforestry Centre has been a driving force in the development of agroforestry in Bulgaria, with the aim of developing a national structure of agroforestry research and education.

2. BENEFITS OF IMPLEMENTING AGROFORESTRY IN RURAL TERRITORIES

FAO recognizes that agroforestry integrating agricultural and forestry systems can provide sustainable multifunctional systems providing and sustaining a diversity of ecological, economic and cultural benefits (FAO, n.d.). Changing environmental conditions lead to better agricultural and forest resources that support rural development. At the same time, agroforestry activities are full of social content that is built from the socio-economic context of rural areas. They are the livelihood of rural people and are the result of wise choices by farmers. In this sense, agroforestry not only has an agricultural character, but also appears as a social system.

2.1. Environmental benefits

The environmental benefits of agroforestry can be sought in a number of environmentally friendly directions in rural territories:

1. Soil conservation and maintenance.
2. Provide ecosystem services.
3. Supports biodiversity.
4. Climate change mitigation and adaptation.
5. Agroforestry can also play a significant role as a source of bioenergy.

2.2. Economic benefits

The economic benefits of agroforestry for farmers stem from its multifunctional characteristics, improving the efficiency of farming systems. The temporal and spatial scales, together with the farmer's experience and financial capacity, determine the economic impact of agroforestry in the following areas:

1. Agroforestry systems can lead to increased agricultural productivity for farmers.
2. Agroforestry can provide diversification of agricultural products.
3. Agroforestry can provide opportunities for recreational activities.
4. Trees and shrubs used in agroforestry are also beneficial to animal welfare.

2.3. Social benefits

The social benefits of agroforestry derive from the economic and environmental benefits that increase the attractiveness of the land use and landscape and create higher cultural value:

1. Improving land use creates higher land values, which helps increase farmers' welfare.
2. Agroforestry creates the conditions on the one hand to sustain the livelihoods of the local population.
3. Agroforestry has the potential to contribute to the conservation of rural landscapes, which is a prerequisite for their management in a cultural way.
4. Agroforestry contributes to improving food security in rural areas.

Knowledge of the benefits of adopting agroforestry practices are key to understanding them and shaping rural development policy elements.

3. STATUS, PROSPECTS AND SUPPORT OF AGROFORESTRY BY THE EU COMMON AGRICULTURAL POLICY

3.1. State of agroforestry in the EU

As a practice, agroforestry has been practiced since ancient times on all continents. According to (FAO, n.d.), this practice is carried out by 1.2 billion people, on about 1 billion hectares of land, mainly in tropical climate zones. In the European Union, agroforestry areas were mapped using LUCAS land use and land cover data over three years between 2009 and 2021. (Eurostat, 2015, 2022) Estimates of the total agroforestry area in the EU-27 are around 15.4 million ha, equivalent to around 3.6% of the territorial area and 8.8% of the utilised agricultural area. According to a 2017 study (den Herder, et al., 2017), agroforestry combined with livestock covers about 15.1 million ha, which is the largest area, high value tree agroforestry and arable agroforestry cover 1.1 and 0.3 million ha respectively. A cluster analysis allows comparisons to be made between countries and to identify regions in Europe where agroforestry is already widely practised and areas where there are opportunities to practise agroforestry on a larger area and introduce new practices. Arable agroforestry covers about 358 000 hectares, corresponding to about 0.1% of the EU's territorial area and 0.39% of arable land. Agroforestry systems with livestock cover about 15.1 million hectares, corresponding to about 3.5% of the EU's territorial area. This amounts to approximately 15% of European grassland, but up to 35% of actual grassland. Agroforestry, including high-value trees, covers about 1.1 million hectares, corresponding to about 0.2% of the EU's land area. Producing assessments of European agroforestry is important for developing measures and policies to promote this practice of sustainable land use and for assessing the impact of certain measures on agroforestry (Augère-Granier, 2020).

The analysis of agroforestry in the EU can be extended to the new average farm, according to the Farm Accountancy Data Network (FADN) (Table 1). Expenditure on on-farm forestry activities is almost doubling, with an increase in forest-related output and wood processing from €257 in 2014 to €378 in 2022. Over the same period, forest areas increase from 1 to 1.5 ha. on average per farm. The share of expenditure on forestry activities is constant at 0.1%, and the share of output in off-farm production averages around 6.1%. The share of agricultural land covered by tree species averages 3.2%.

Table 1. Agroforestry in agricultural holdings in EU, average per farm, 2014-2022

	Year	(SE331) Forestry specific costs (€)	(SE715) Forestry and wood proces-sing (€)	(SE025) Total Utilised Agricul-tural Area (ha)	(SE075) Woodland area (ha)	Share of total forestry cost from total specif. cost	Share of forestry and wood processing in other production	Share of wood-land area in total agricul-tural area
EU=27	2014	32	257	31,2	1,0	0,1%	7,2%	3,2%
EU=27	2015	32	261	31,7	1,1	0,1%	6,7%	3,3%
EU=27	2016	30	248	31,9	1,1	0,1%	6,5%	3,4%
EU=27	2017	29	241	32,4	1,0	0,1%	6,2%	3,1%
EU=27	2018	37	297	40,1	1,2	0,1%	6,1%	2,9%
EU=27	2019	44	269	40,1	1,2	0,1%	5,3%	2,9%
EU=27	2020	40	252	40,3	1,2	0,1%	4,9%	3,0%
EU=27	2021	48	403	40,3	1,2	0,1%	7,2%	3,0%
EU=27	2022	60	378	40,4	1,5	0,1%	5,3%	3,7%
Average		39	290	36,5	1,2	0,1%	6,1%	3,2%
Min		29	241	31,2	1,0	0,1%	4,9%	2,9%
Max		60	403	40,4	1,5	0,1%	7,2%	3,7%
Median		37	261	40,1	1,2	0,1%	6,2%	3,1%
St. Dev.		10	56	4,2	0,1	0,0%	0,8%	0,2%

Source: FADN and own calculation

Austria has the highest forest specific cost per farm, followed by Denmark, Latvia, Slovakia, Estonia, with an EU=27 average of 39.1€/per farm. In nine countries data are missing. In terms of output from forestry and wood processing, Austria has the highest, followed by Slovenia, Estonia, Germany, Latvia, with EU average=27 290 €/per farm. In eight countries data are missing. Forest land on farms is highest in Austria, Estonia, Latvia, Slovenia and Luxembourg, with an EU=27 average of 1.2 ha. In ten countries data are missing (Figure 1). Unfortunately, no data are reported for Bulgaria.

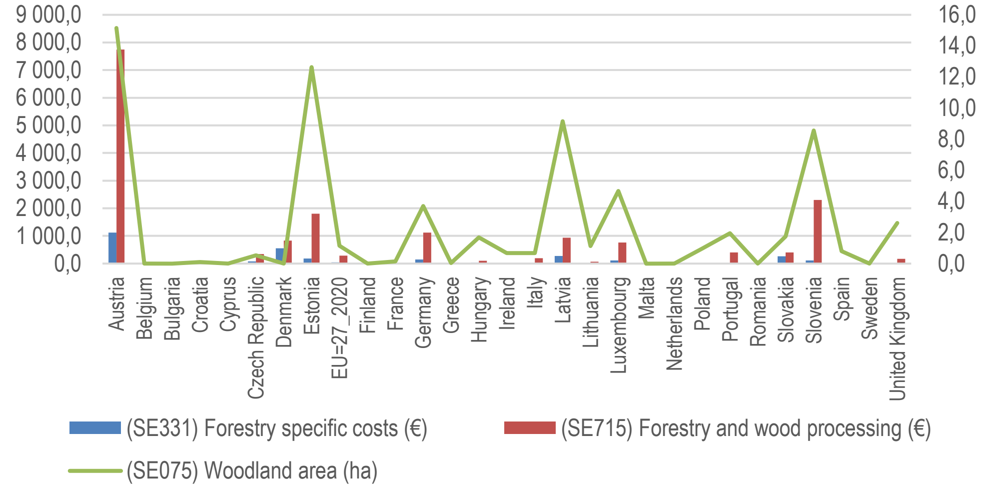

Figure 1. Forestry (Cost, production, woodland area) in agricultural holdings by country, 2022

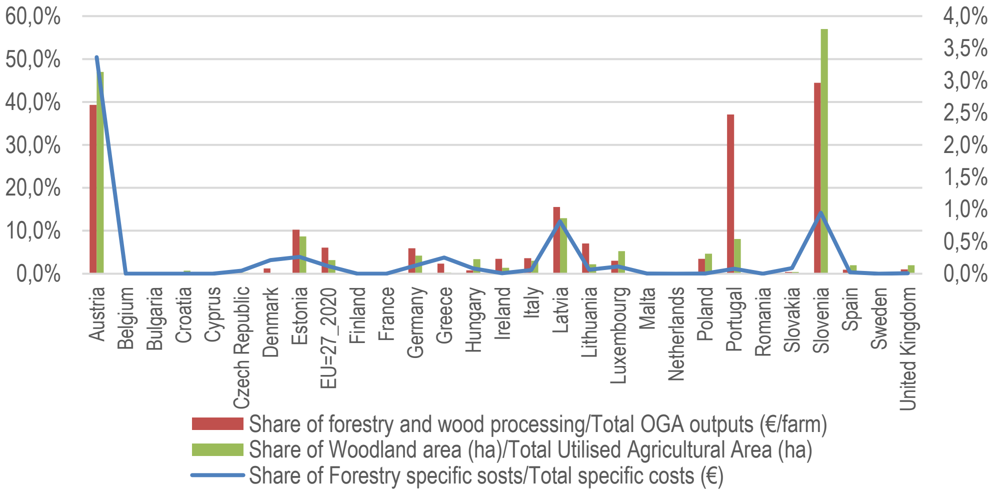

Figure 2. Forestry (share) in agricultural holdings by country, 2022

The highest share of forestry specific cost in total specific cost is observed in Austria, followed by Slovenia, Latvia, Estonia, Greece, with EU=27 average 0.1%. The share of forestry and wood processing in total non-agricultural production is highest in Slovenia, followed by Austria, Portugal, Latvia and Estonia, with an EU=27 average of 6.1%. The share of woodland area in total agricultural area is in Slovenia, followed by Austria, Latvia, Estonia and Portugal, with an EU=27 average of 3.2% (Figure 2).

3.2. EU policy to support agroforestry

Agroforestry enjoys recognition and support at EU level from the Common Agricultural Policy (CAP). Farmers can receive direct payments per hectare of land for agroforestry, as well as support for establishing or maintaining agroforestry systems under the rural development strand of the CAP. The high environmental and social value of agroforestry was only recognised at EU level in 2005. In the 2007-2013 programming period, agroforestry was included among the forestry measures to be supported in Member States' rural development plans, but with limited relevance. In the 2014-2020 programming period, farmers and foresters receive support from both pillars of the current CAP. As a sustainable practice providing many environmental services, agroforestry can contribute to the three objectives of the current CAP: viable food production, sustainable management of natural resources and climate action and balanced territorial development. In 2017, Regulation 2017/2393 contributed to improving the eligibility of agroforestry under the CAP.

The agroforestry policy framework post 2023 to 2027 has shifted the focus towards efficiency and provided more flexibility to Member States in developing their strategic plans. In the current programming period, agroforestry is included in the new "green architecture" of the CAP and in the EU Forestry Strategy. Support has been maintained through both direct payments and agri-environmental climate schemes. Agroforestry occupies an increasingly broad policy framework in key building blocks of the European Green Pact - the Farm to Fork Strategy and the Biodiversity Strategy. Agroforestry has found an important place in the implementation of carbon farming. The need for a European agroforestry strategy is increasingly clear to provide a framework to be recognised by Member States, with the possibility of acknowledging the delivery of ecosystem services (Mosquera-Losada & all, 2023).

3.3. Policy to support agroforestry in Bulgaria

The main normative document in Bulgaria defining the elements of the agroforestry system is Regulation 3 of 10.03.2023 on the implementation of interventions in the form of direct payments included in the Strategic Plan for the RDP. Within the framework of the norms, agroforestry systems are distinguished by a set of farming systems in which species of perennial trees or shrubs are cultivated, with a maximum number of 100 trees. Agroforestry systems include farming systems, silvopastoral systems, forestry farming, alley system, buffer strips or strips, riparian buffer strips, buffer strips. The application of agroforestry practices may take place in agricultural areas, permanent crops and permanent grassland. Bulgaria's new strategic plan includes 10 forestry interventions, with only one targeting agroforestry - intervention I.C.7 - Eco-scheme for maintaining and improving biodiversity in forest ecosystems. Beneficiaries are farmers who qualify as active farmers. The intervention is aimed at maintaining and improving biodiversity in forest ecosystems by introducing the practice of growing crops on marginal agricultural land that have reached a maturity that is favourable for wildlife feeding. The planned amount is €215/ha, against a budget of €4,366 thousand.

4. CONCLUSION

Agroforestry can be a sustainable alternative to traditional farming practices by reducing negative impacts to some extent by protecting and maintaining environmental factors. In terms of environmental benefits, agroforestry has the potential to contribute to several of the nine objectives by: contributing to climate change mitigation and adaptation, and sustainable energy; promoting sustainable development and efficient management of natural resources such as water, soil and air; contributing to biodiversity conservation, improving ecosystem services and protecting habitats and landscapes; promoting employment, growth, social inclusion and local development in rural areas; and promoting the development of sustainable agriculture. Areas for development in this direction are raising social awareness, promoting agroforestry education and extension at all levels, improving access to data for decision making, knowledge provision, etc. Economic incentives (subsidies, grants, taxes and schemes) need to be improved to recognise and compensate for the benefits provided by agroforestry. With an integrated development approach, rural areas can benefit more fully from the benefits of agroforestry.

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REFERENCES

1. Augère-Granier, M.-L. (June 2020 r.). *Agroforestry in the European Union*. Brifing, PE 651.982. European Parliamentary Research Service.
2. Burgess, P., den Herder, M. D., Garnett, K., Giannitsopoulos, M., Graves, A., Hermansen, J., . . . Plieninger, T. (2018). *AGFORWARD PROJECT*. Cranfield University: AGFORWARD.
3. den Herder, M., Moreno, G., Mosquera-Lozado, R. M., Palma, J. H., Sidiropoulou, A., Freijanes, J. J., & ... & Burgess, P. (2017). *Current extent and stratification of agroforestry in the European Union*. Agriculture, Ecosystems & Environment, 121-132.
4. EIP-AGRI. (December 2017). EIP-AGRI Focus Group. *Agroforestry: introducing woody vegetation into specialised crop and livestock systems*.
5. Eurostat. (2015, 2022). *Analysis of LUCAS information related to Agroforestry*. Methodological support for the LUCAS project. GOPA Consultants, Bad Homburg, Germany.
6. FAO and ICRAF. (2019). *Agroforestry and tenure*. Forestry Working Paper No8, Rome.
7. Jatav, H., Rajput, V., Minkina, T., Van Hullebusch, E., & Dutta, A. (Ed.). (2024). *Agroforestry to Combat Global Challenges*. Singapore: Springer Singapore.
8. Kachova, V.; Hinkov, G.; Popov, E.; Trichkov, L.; Mosquera-Losada, R. (2016). *Agroforestry in Bulgaria: history, presence status and prospects*. Agroforest Syst.
9. Mosquera-Losada, M., & all, e. (2023). *Policy challenges for agroforestry implementation in Europe*. Front. For. Glob. Change, 6:1127601.
10. Mosquera-Losada, M., Moreno, G., Pardini, A., McAdam, J., Papanastasis, V., Burgess, P., . . . Rigueiro-Rodríguez, A. (2012). *Past, present and future of agroforestry systems in Europe*. In e. In P.K.R. Nair & D. Garrity (Ed.), Agroforestry - The Future of Global Land Use (pp. 285–312). Dordrecht, Germany: Springer Science+Business Media.
11. Nair, P. (1993). *An Introduction to Agroforestry*. Dordrecht, The Netherlands: Kluwer Academic Publishers.
12. Nair, P. K., Gordon, A. M., & Mosquera-Losada, M. R. (2008). *Agroforestry*. Ecological Engineering. Encyclopedia of Ecology, 1, 101-110. (S. E. Jorgensen, Ред.) Oxford, U.K.: Elsevier.

13. Nair, P., & Garrity, D. e. (Eds.). (2012). *Agroforestry - The Future of Global Land Use*. Dordrecht, Germany: Springer Science+Business Media Dordrecht.
14. Nair, P., Kumar, V., & Nair, V. (2021). *An Introduction to Agroforestry* (2 ed.). Springer
15. Ramil Brick, E., Holland, J., Anagnostou, D., B. K., & Desmulliez, M. (2022). *A review of agroforestry, precision agriculture, and precision livestock farming — The case for a data-driven agroforestry strategy*. Frontiers in Sensors, 3, 1-25.
16. Rigueiro-Rodríguez, A., Fernández-Núnez, E., González-Hernández, P., McAdam, J., & Mosquera-Losada, M. (2009). *Agroforestry Systems in Europe: Productive, Ecological and Social Perspectives*. Agroforestry in Europe: Current Status and Future Prospects, p. 43-65, Springer Science + Business Media B.V.
17. AGFORWARD (AGroFORestry that Will Advance Rural Development). Retrieded march 2024, https://www.agforward.eu/index.html
18. SIFOR-ICRAF. (n.q.). Trees people planet. Retrieved march 2024 r. https://www.cifor-icraf.org/
19. FAO. (n.q). Food and Agricilture Organization of the United Nations. Retrieved 2024 Agroforestry: https://www.fao.org/forestry-fao/agroforestry/en/

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DEVELOPMENT OF A COMPREHENSIVE INDICATOR SYSTEM FOR MONITORING SUSTAINABLE TOURISM IN FORESTRY-BASED ENVIRONMENTS

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Abstract: This research aims to develop a comprehensive indicator system for monitoring sustainable tourism in forestry-based environments. The study will focus on identifying key indicators and methodologies to assess the impact of tourism on economic, social, and ecological aspects within the context of forestry. The research will involve an analysis of theoretical sources, existing practices worldwide, and the specific conditions and factors influencing forestry-based tourism. The investigation will address various aspects, including the effectiveness of tourist demand, tourism offerings (infrastructure, services, enterprises), and the overall impact of tourism on sustainability, carrying capacity, and resource potential.
Keywords: indicators, sustainable tourism, forest-based tourism, monitoring

1. INTRODUCTION

Forests play an essential role in the well-being of humanity by providing a wide range of ecosystem services and they have exceptional cultural and recreational importance. The wise multifunctional use and the protection of forests are the main policy challenges for their sustainable management.

The literature search across global databases revealed that few publications address indicators for monitoring sustainable forest tourism development. Notably, existing systems seem inadequate for assessing environmental sustainability in this specific context. In addition, just a few publications provide empirical evidence on the positive or negative impacts of tourism and recreation on forests (Brandt and Buckley, 2018). Kuvan (2005) emphasizes that minimizing tourism's negative impacts on forests requires a deep understanding of how tourism activities create these impacts. The review of a number of studies discussing the issue indicates that it is not sufficiently researched, it is complex and ambiguous, and there are serious barriers to deriving a system of indicators for tourism in a forest environment, mainly due to the specifics of the environment. For the above reasons this research aims to develop a concept for a comprehensive indicator system for monitoring sustainable tourism in forestry-based environments through integration of up-to-date research from different domains.

2. RESEARCH METHOD

The fulfilment of the research aim requires the following tasks to be performed: 1) Define the scope, specifics, impacts and monitoring of tourism in forest-based environments; 2) Identify indicators for monitoring the aspects of sustainability relevant for forest-based environments; and 3) Elaborate a conceptual model for a comprehensive indicator system for monitoring sustainable tourism in forestry-based environments.

The research approach is grounded on a thorough review of scientific publications, covering forest-based tourism and its monitoring on one hand, and on the other – existing systems of indicators for monitoring sustainable tourism. Two sets of keywords have been used to find relevant publications, namely “tourism development indicators monitoring” and “indicator monitoring sustainable forest tourism”.

3. FOREST-BASED TOURISM – SCOPE, SPECIFICS, IMPACTS AND MONITORING

Forest-based tourism is associated with a variety of recreational activity types. In all cases, the forests appear as a critical latent primary factor for tourism production (Marcouiller, 1998) because forests comprise tourism's natural capital and supply raw materials, and the forest itself is a touristic and recreational product (Kuvan, 2005). Buultjens et al. (2003) outline some specifics of the forest-based tourism industry located in rural, often mountainous environment and in protected areas.

Alam et al. (2010) emphasize the importance of stakeholder conflicts in forest environment. Pröbstl et al. (2009) outline five main conflict types typical of forest-based tourism: recreation vs nature protection, forest use, different user groups, hunting and fishing, and crowding. The most frequently mentioned positive impacts related to forest-based tourism are providing rural development (Buultjens et al., 2003), social well-being (Pröbstl et al., 2009), forest protection, re-forestation (Brandt & Buckley, 2018; Alam et al., 2010), natural resource conservation activities, preservation of biodiversity (Zoysa, 2022). The environmental adverse impacts of forest-based tourism are the most frequently highlighted in the literature - deforestation, forest allocation, forest ecosystem degradation (Kuvan, 2005; Brandt & Buckley, 2018), gene piracy, wildlife crimes, and trade of protected flora and fauna (Zoysa, 2022), vegetation trampling, soil compaction (Deng et al., 2003; Turton, 2005), water contamination and soil erosion, the spread of weeds, feral animals and soil pathogens (Turton, 2005), the emergence of introduced, invasive and alien plant species (Pongpattananurak, 2018). Marion et al. (2016) synthesized the progress of recreation ecology on adverse visitor impacts on vegetation, soils, water, and wildlife in wilderness and protected areas, including forest areas.

Indicator systems specifically for monitoring sustainable forest-based tourism have been developed or presented in several studies such as by Ahtikoski et al. (2011), González et al. (2019), Mapjabil et al. (2015), Mearns (2015), Mutana and Mukwada (2017), Lee et al. (2021). All of them provide valuable insights and tools for assessing and monitoring the sustainability of forest-based tourism, including indicators related to service quality, environmental sustainability, socio-cultural sustainability, and biodiversity conservation. Given the multifaceted nature of forestry-based tourism, developing a comprehensive indicator system for monitoring sustainable tourism development in forest environments poses significant challenges due to the complexity of forest management and tourism impacts.

4. INDICATORS FOR MONITORING SUSTAINABLE TOURISM IN FOREST-BASED ENVIRONMENTS

Socio-economic indicators for sustainable tourism development in forest regions should reflect the characteristics of forest territories in general and of specific regions in particular, consider the carrying capacity and load pressure on resources, and measure current tourism demand and supply. Primarily they reveal the satisfaction of social needs and the economic benefits obtained by various social groups, interested parties and stakeholders (visitors, local population, staff, etc.). Socio-economic indicators for sustainable tourism development in forest areas are thus related to the number and satisfaction of visitors and local population, the safety of people in the respective territory, the tourism enterprises that serve visitors, as well as the number and qualifications of their staff, the provided infrastructure, activities and services, the capacity and load of resources, the type and quality of information materials and the content of information provided to tourists, revenues, costs, wages, investments, etc. The identified most important socio-economic indicators, applicable for monitoring sustainable tourism development in forest areas, fall in several groups presented in Table. 1.

Table 1. Classification of socio-economic and environmental indicators

Social and economic indicators related to:	Environmental indicators related to:
- Local population and visitor demographics, including population numbers and ratios, incl. their satisfaction within the destinations - Tourism supply: availability, access, quantity and quality of tourism enterprises, infrastructure, sites, activities, products, and services - Employment and staff in tourism - Information provided to visitors - Income, revenue, costs, investment, wages	- Air quality, noise pollution, energy consumption and waste management - Terrain preservation and soil quality - Biodiversity conservation - Deforestation/reforestation caused by tourism development - Forest health in relation to tourism activities - Trampling and trail degradation/erosion

Source: authors own elaboration

Environmental indicators for monitoring sustainable tourism development are related to the capacity and use of natural resources, state of natural environment and the levels of conservation, protection, reduction of use, consumption, quality and pollution of nature and natural resources, such as air, water, energy, land, terrain, soils, flora, and fauna. These indicators reflect the environmental benefits and costs that are realized due to tourism development at destinations. Environmental indicators for monitoring sustainable tourism development of destinations, classified in groups according to core criteria related to the type and effects on natural resources, are presented in Table 1.

Sustainable tourism management in forest environments requires the availability of sufficient, detailed, quality, up-to-date, timely, and reliable information for monitoring and informed decision-making and evidence-based policy-making. The identified indicators are both qualitative and quantitative. The respective values of the indicators could be obtained or derived from statistical data and studies, data on the Internet, administrative data and data collected at tourism sites, primary information obtained by regular or ad-hoc surveys, etc. There are already examples of research, demonstrating the use of available information from social media and GIS-based data regarding tourism in forest-based environments, proving that it can serve as a reliable alternative for empirical data. (Wood et al., 2013; Liang et al.,2023). Passive mobile and GPS data provide information not only on the number of visitors but enable the assessment of inter-regional and intra-regional tourist flows and their spatio-temporal behavior (Hardy, 2020; Reif and Schmücker, 2020). Unmanned aerial vehicles (UAV) as a geospatial technology is increasingly being used in various scientific studies of forest territories. Thus, an information system to feed the monitoring of the selected indicators should consider including the following information sources, depending on the objectives, selected indicators and cost: 1) Secondary data – statistics, reports and studies, administrative data; 2) Primary data – surveys of visitors, data collected at tourism sites and tourist attractions; 3) Social media, GIS-based data and UAV; 4) Stakeholder's own internal information.

5. CONCEPT FOR A COMPREHENSIVE INDICATOR SYSTEM FOR MONITORING SUSTAINABLE TOURISM IN FORESTRY-BASED ENVIRONMENTS

The proposed concept for developing a comprehensive indicator system for monitoring sustainable tourism in forestry-based environments integrates the knowledge of forest-based tourism and the application of indicator systems for monitoring sustainable tourism (Fig. 1). The conceptual model for developing the respective indicator system is regarded as a process, comprising several consecutive and interrelated steps, starting with defining the state and conditions of the forest environment, the respective types of activity and their impacts.

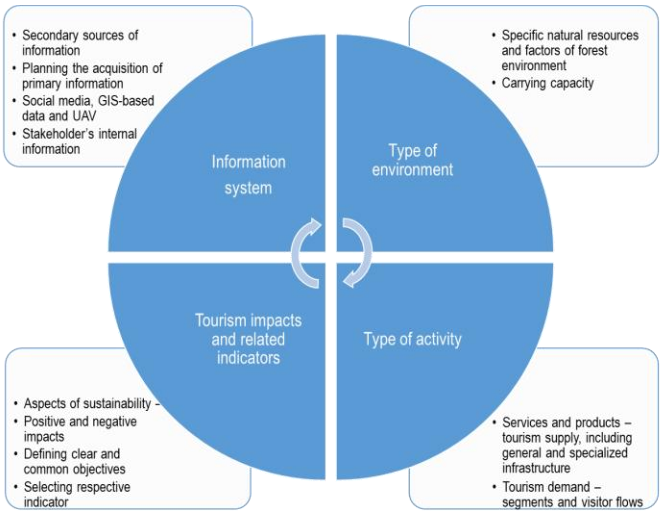

Figure 1. Conceptual model for a comprehensive indicator system for monitoring sustainable tourism in forestry-based environments

Due to the environmental specifics of each forest destination it is not possible to develop and apply a unified system of indicators. From a methodological and systematic point of view it is also important to define what are the main objectives and what should be measured, monitored and managed? Residents of destinations should be involved in defining what should be measured as they are the affected by tourism development (Butler, 2022), especially in environmentally sensitive destinations. Based on these answers the selection of adequate indicators is possible encompassing the economic, social, and ecological dimensions.

Identifying and defining indicators to effectively monitor the impact of tourism on economic, social, and ecological aspects involves a systematic process that considers the specific context of the destination and the objectives of sustainable tourism management. The indicators selected should produce desired, comparable results, they should be useful for measuring and monitoring tourism impacts. Each forest destination can choose the most relevant indicators to be adopted and monitored in order to meet the needs of the destinations, the interests of local stakeholders and the specific sustainability issues that the destination faces. This requires relevant stakeholders' engagement, including local communities, government agencies, tourism operators, conservation organizations, and academic institutions, to identify key concerns and priorities related to tourism impacts.

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REFERENCES

1. Ahtikoski A.; Tuulentie, S.; Hallikainen, V.; Nivala, V.; Vatanen, E.; Tyrväinen, L.; Salminen, H.: *Potential Trade-Offs Between Nature-Based Tourism and Forestry, a Case Study in Northern Finland.* Forests. 2011; 2(4):894-912. DOI: 10.3390/f2040894
2. Alam, M.; Furukawa, Y.; & Akter, S. (2010): *Forest-based tourism in Bangladesh: Status, problems, and prospects*. Tourismos, 5(1), 163-172.
3. Buultjens, J.; Tiyce, M.; Gale, D. (2003): *Sustainable forest-based tourism in Northeast New South Wales, Australia: a problematic goal*. Tourism Review International, 7(1), 1-12.
4. Brandt, J.; Buckley, C. (2018): *A global systematic review of empirical evidence of ecotourism impacts on forests in biodiversity hotspots*. Current Opinion in Environmental Sustainability 2018, 32:112–118.
5. Butler, R. (2022:) *Measuring tourism success: alternative considerations*, Worldwide Hospitality and Tourism Themes, Vol. 14 No. 1, pp. 11-19. https://doi.org/10.1108/WHATT-10-2021-0133.
6. Deng, J.; Qiang, S.; Walker, G. ; Zhang, Y. (2003): *Assessment on and perception of visitors' environmental impacts of nature tourism: A case study of Zhangjiajie National Forest Park, China*. Journal of sustainable tourism, 11(6), 529-548.
7. González, A.J.; Macías Egas, A.; Ramos Rodríguez, M.; Tapia Zúñiga, M.; Blandariz, S. (2019): Indicators of sustainability with emphasis on the state of conservation of the tropical dry forest. Cuban Journal of Forest Science, 7(2): 197-211.
8. Hardy, A. (2020): *Tracking tourists: Movement and mobility*. Wolvercote Oxford: Goodfellow Publishers Ltd., eBook DOI: 10.23912/9781911635383-4277.
9. Kuvan, Y. (2005): *The use of forests for the purpose of tourism: the case of Belek Tourism Center in Turkey*. Journal of Environmental Management, 75:3, 263-274, https://doi.org/10.1016/j.jenvman.2005.01.003.
10. Lee, T.; Jan, F.; Liu, J. (2021): *Developing an indicator framework for assessing sustainable tourism: Evidence from a Taiwan ecological resort*. Ecological Indicators 125, 107596.
11. Liang, Y.; Yin, S.; Park, B.; Pan, G.; Miller, Z. (2023): *Using social media user profiles to identify visitor demographics and origins in Yellowstone national park*. Journal of Outdoor Recreation and Tourism, Volume 44, Part A, 2023, 100620, https://doi.org/10.1016/j.jort.2023.100620.
12. Mapjabil, J.; Marzuki, M.; MohdZainol, R.; Mat Jusoh, A.T.; Ramli, R.R. (2015): *Applying sustainability indicators to eco-tourism development: the case of Jeram Linang Amenity Forest, Kelantan*. Malaysian Journal of Society and Space, 11(12), 64-73.
13. Marcouiller, D. W. (1998): Environmental resources as latent primary factors of production in tourism: the case of forest-based commercial recreation. Tourism Economics, 4(2), 131-145.

14. Marion, J. L.; Leung, Y. F.; Eagleston, H.; Burroughs, K. (2016): A review and synthesis of recreation ecology research findings on visitor impacts to wilderness and protected natural areas. Journal of forestry, 114(3), 352-362.
15. Mearns, K. (2015): *Applying sustainable tourism indicators to community-based ecotourism ventures in Southern Africa*. Athens Journal of Tourism, v. 2 (3), 179-194.
16. Mutana, S.; Mukwada, G. (2017): *An Exploratory Assessment of Significant Tourism Sustainability Indicators for a Montane-Based Route in the Drakensberg Mountains*. Sustainability 9, 1202; doi:10.3390/su9071202.
17. Pongpattananurak, N. (2018): *Impacts from tourism development and agriculture on forest degradation in Thap Lan National Park and adjacent areas*. Agriculture and Natural Resources, 52(3), 290-297.
18. Pröbstl, U.; Elands, B.; Wirth, K. (2009): *Forest recreation and nature tourism in Europe: context, history and current situation*. In: European Forest Recreation and Tourism (Eds. S. Bell, M. Simpson, L. Tyrväinen, T. Sievänen, U. Pröbstl), Taylor & Francis, 12-32.
19. Reif J.; Schmücker D. (2020): *Exploring new ways of visitor tracking using big data sources: Opportunities and limits of passive mobile data for tourism*, Journal of Destination Marketing & Management, Volume 18, 2020, 100481, https://doi.org/10.1016/j.jdmm.2020.100481.
20. Turton, S. (2005): *Managing environmental impacts of recreation and tourism in rainforests of the wet tropics of Queensland World Heritage Area*. Geographical research, 43.2: 140-151.
21. Wood, S.; Guerry, A.; Silver, J.; Lacayo, M. (2013): *Using social media to quantify nature-based tourism and recreation*. Scientific reports, 3(1), 2976.
22. Zoysa, M. D. (2022): Forest-based ecotourism in Sri Lanka: a review on state of governance, livelihoods, and forest conservation outcomes. Journal of Sustainable Forestry, 41(3-5), 413-439.

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GREEN DEAL INITIATIVES, CLIMATE CHANGE SOLUTIONS, AUDITING CONTROL AND ESG REPORTING

INVENTORY OF WOOD ENERGY CONSUMPTION AND GHG EMISSIONS FROM WOOD FUELS IN VOJVODINA

Branko Glavonjić, Aleksandra Lazarević, Miljan Kalem

Abstract: Vojvodina is one of the five regions in Serbia, with a population of around 1.9 million residents. By this indicator, Vojvodina is the second-largest region in Serbia. However, with approximately 0.7 million active households, Vojvodina leads the regions in Serbia. Despite the fact that the forest cover in this region is only 7.97%, and gasification has been implemented in many populated areas, close to 40% of households in this region still use wood as a heating fuel. This makes this region interesting for research regarding wood fuel consumption.
The results of the conducted research have shown that the consumption of firewood in 2021 amounted to 1.62 million cubic meters, and wood pellets were around 52 thousand tons. The average firewood consumption per household in urban areas was 6.3 cubic meters, while in rural areas, it was 6.9 cubic meters. Translated into energy efficiency parameters, the average consumption of wood energy per 1 square meter of the heated area in urban areas was 199 kWh, and in rural areas, it was 214.5 kWh.
The consumption of wood energy in the households measured in kWh/m^2 of the heated area is not satisfactory in this region. Its values are beyond the values of the last class of the energy passport for residential buildings [G class > 188 kWh/m^2 (a)].
Key words: inventory, energy, wood, households, consumption.

1. INTRODUCTION

Monitoring the consumption of wood fuels and the greenhouse gas (GHG) emissions resulting from their combustion has become a subject of interest for policymakers, experts, and the scientific community in Serbia over the past decade. The reasons are numerous, with one of the most significant being Serbia's reporting to international organizations responsible for monitoring climate change and, consequently, GHG emissions tracking. For this reason, several projects have been implemented in the last ten years with the aim of inventorying wood energy consumption in Serbia as a whole and its individual regions.

The data from the latest project, carried out in 2021, were used for the development of the Integrated National Energy and Climate Plan of the Republic of Serbia until 2030 with a vision for 2050 [1] and [2].

Wood energy represents one of the most important forms of energy from renewable sources used for heating purposes in Serbia, making a significant contribution to achieving Serbia's projected goal of a 41% share of energy from renewable sources in total gross final energy consumption by 2030. This paper presents the results of research on wood energy consumption in the Vojvodina region (the second-largest region in Serbia), obtained through the implementation of a project within the national forest inventory and with the support of the FAO organization.

2. MATERIALS AND METHODS

The research aimed to collect data on types, amounts, and values of wood fuels being consumed in the Vojvodina region, as well as GHG emissions from their combustion.

The research included t*he most important categories of wood energy consumers: (i) households (urban and other), (ii) public buildings (schools, health-care centres, ambulances, kinder gardens, local government facilities, etc.), (iii) commercial buildings (restaurants, meat roasters, bakeries, car repair services, shops, business facilities, etc.), and (iv) wood fuels producers (producers of pellets, briquettes, wood chips).*

Based on the results the corresponding balance of GHG emissions was developed. The inventory included a calculation of the emissions of carbon dioxide and nitrogen oxides.

In accordance with the set research objectives and chosen consumer categories, an appropriate methodological concept has been developed. This concept is based on the WISDOM methodology, which has been applied in numerous FAO projects in the Western Balkans and beyond. The essence of this methodology lies in defining a sample for the purpose of surveying households and other consumer categories. Regarding households, the sample was obtained by subtracting the number of households using gas, district heating systems, electricity, and heating oil from the total number of households in this region. This way, the number of households using solid fuels (wood fuels and coal) was determined. This derived number of households was the focus of the research, and all wood fuel consumption was calculated in relation to this number of households. As for other consumer categories, efforts were made to include as many facilities using wood fuels as possible to obtain a more realistic picture of their consumption.

Consistent with the above mentioned, the household survey sample covered 701 households, with 449 households in urban areas and 252 in rural areas. Households in the sample were selected based on the principle of random sampling from the appropriate database using relevant statistical tools. A survey on wood and wood fuel consumption in public and commercial buildings had the intention to ensure proper geographical distribution in the entire selected region.

The collection of data on wood fuel consumption and characteristics of buildings and appliances for wood fuels combustion was conducted using the appropriate questionnaire. Households were interviewed between April 20th and June 15th 2021.

The calculation of the GHG emissions from the wood fuels combustion process in the chosen region was based on the IPCC 2006 methodology and additions from the corresponding European standards, relevant scientific papers and publications measurements from practice.

3. RESEARCH RESULTS AND DISCUSSION

The most significant category of consumers of wood fuels in Vojvodina is represented by households. In addition to them, consumers of wood fuels also include public facilities (schools, kindergartens, health centers), commercial facilities, and industry. In this context, firewood represents the fuel with the highest consumption compared to other types of wood fuels.

One of the specific features of wood fuel consumption in households in Vojvodina is that they often combine firewood and briquettes with agro biomass.That is reasonable since this is a region with a lot of agricultural soil. Every year residuals of wheat, corn, sunflower, soy and other agricultural cultures are numerous and are used for energy purposes. Furthermore, the combinations of gas (LPG) and wood fuels are also very spread in Vojvodina. Fig. 1 depicts the share of combinations of solid fuels in households per county in Vojvodina.

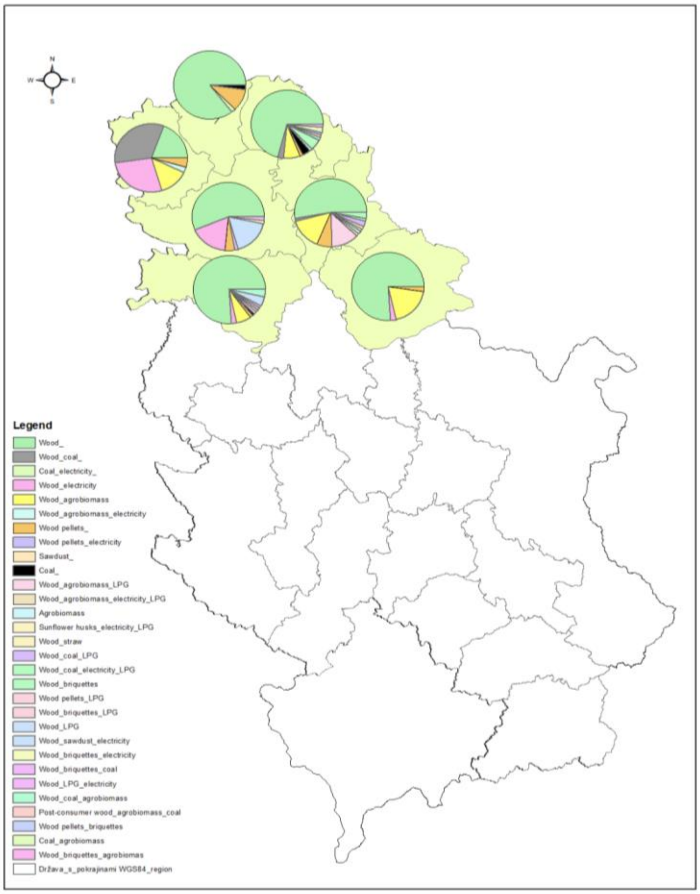

Figure 1. Overview of certain fuel types consumed for heating households in Vojvodina (Glavonjić, 2022)

As it could be seen, in all counties except in Western Bačka, firewood is a dominant fuel consumed by households for heating. Its share is in the range from 40.2% in Middle Banat to 74% in Nord Bačka. In Western Bačka, the households predominantly combine wood and coal (31.1%) and wood and electricity (26.1%) for heating. The share of households that consume only firewood is18.5%.

The second important characteristic of the fuel consumption in Vojvodina is the variety of the combinations. According to the survey conducted within the FAO project, 30 different combinations of fuels have been registered. The households in this region may use only one or combine up to four different fuels (e.g. wood, coal, electricity and gas/LPG). The combinations of two or more fuels have been registered in the households with the individual heating appliances which simultaneously heat many rooms.

The third characteristic of the fuel consumption in Vojvodina is a high share of the agro biomass in the forms of cobs, straw and sunflower husks, as well as grainy residues. The agro biomass is mostly combined with firewood. The share of households that combine firewood and agro biomass for heating is predominantly spread in South Banat, Middle Banat and Western Bačka. The total consumption of wood fuels in households in this region was: firewood 1,620,254 m^3, wood pellets: 51,802 tonnes, and wood briquettes 5,004 tonnes. Additionally, in public and commercial facilities, as well as in the industry, 3,547 m^3 of firewood, 984 tonnes of wood pellets, and 37,972 tonnes of sawdust/wood chips were consumed during heating season 2020/2021.

The consumption of wood energy in the households measured in kWh/m^2 of the heated area is not satisfactory in this region. In urban households, the average consumption of wood energy was 199 kWh/m^2, while in rural households it was 214.5 kWh/m^2.

Boths values are beyond the values of the last class of the energy passport for residential buildings [G class > 188 kWh/m^2 (a)].

The high consumption of wood energy in households in Vojvodina is a result of the large area of residential space being heated. According to the results of a conducted survey in households, the average number of rooms in residential facilities (including kitchen, corridor, and WC/toilet) being heated in urban settlements in Vojvodina is 5.6, while in other settlements, it is 5.3. The average area of residential facilities in urban settlements in Vojvodina is 103.4 m^2, and in other settlements, it is 108.5 m^2. The average area being heated in residential facilities during the heating season at the level of Vojvodina is 81.6 m^2 in urban and 82.7 m^2 in other households.

In addition to the size of the heated area, an important factor influencing wood energy consumption is the timing of firewood procurement relative to the begining of the heating season (Figure 2).

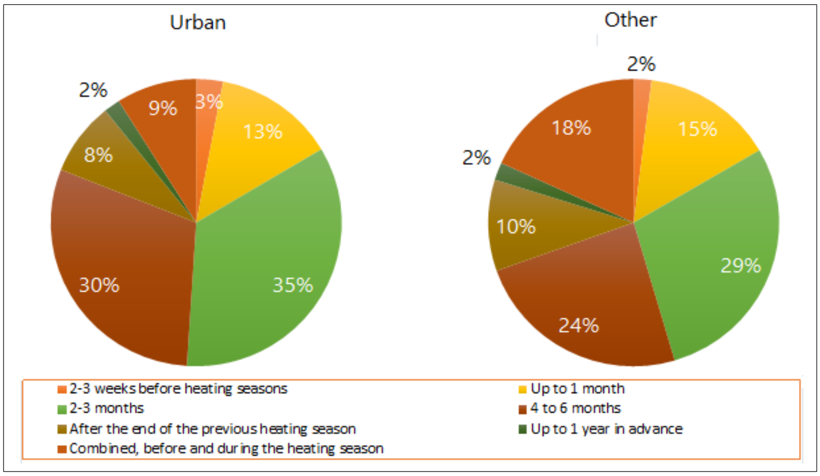

Figure 2. Timing of purchase of firewood by households relative to the beginning of the heating season in Vojvodina

The largest number of urban households in Vojvodina purchased firewood some two to three months before the heating season (35%). The share of households that purchased firewood some four to six months before the heating season is 30%, and those that purchased it right after the end of the previous heating season is 8%. A similar situation is in the households that are located outside urban zones. The share of households that partly purchase firewood before the heating season, and partly during the heating season amounts to 18% (outside urban zone). That is reasonable because of their agricultural works in the summer months.

Considering the question of the complete or partial purchase of wood fuels in Vojvodina, almost 55% of households purchase the wood fuels completely before the heating season, and the rest partially: some of them before the heating season and some of them during the heating season. Since the last three winters were mild, many households decide to partially purchase the wood fuels.

Generally, the firewood purchase by households in Vojvodina is unsatisfactory because only 40% of the urban and 36% of the other households purchase firewood early enough before the heating season so that it can dry to the acceptable and energy-efficient moisture content (below 30%).

On the question "why they consume the fuels they consume", 54% of the households in Vojvodina stated that it is the cheapest solution for them (22%), that their heating appliances need exactly those fuels (18%) and that is easiest for them to purchase exactly those fuels (14%).

The most important wood fuels supply channel for the households from Vojvodina is heating fuels warehouses, from which the wood fuels are provided to 56% of the households. The second important supply channel consists of firewood traders. They supply 26% of the households. The share of other supply channels is under 10%. The remaining 8% of the households from Vojvodina is supplied from the state-owned forests (fig. 3), due to the small forest coverage of the territory in this region.

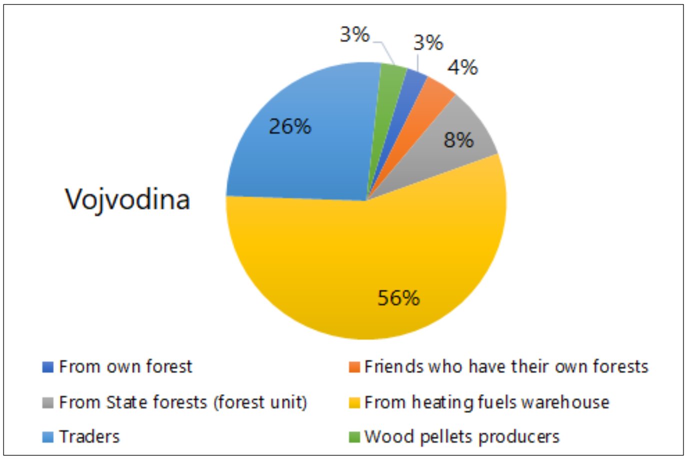

Figure 3. Firewood supply chains of the households in Vojvodina

According to the survey, 68% of the households in Vojvodina consume firewood only for heating, 17% for heating, hot water and cooking, whereas the remaining 15% consume it additionally for the production of brandies and drying of meat and plums.

When it comes to GHG emissions that arise from burning wood fuels, the results of conducted research have shown the following:

- Total CO_2 emissions stemming from the wood fuels combustion in Vojvodina during the heating season 2020/2021 are estimated to 2.05 million tonnes (see table 11). Some 97.6% of these emissions stemmed from households (2 million tonnes of CO_2), whereas the remaining 2.4% stemmed from all other consumers categories.
- The emissions of nitrous oxide (N_2O) were not that high: 67.6 tonnes.
- The emission of sulfur oxides is symbolically low from wood fuels.

4. CONCLUSION

Based on conducted research, it can be concluded that wood fuels represent an important source of energy for households and other consumer categories in Vojvodina. This is especially true for firewood, whose share in wood fuel consumption is dominant, particularly in households.

Although wood fuels are crucial for the energy needs of households, public, and commercial facilities in Vojvodina, their usage efficiency is not satisfactory. This is particularly applicable to firewood. There are three dominant factors contributing to the unsatisfactory efficiency of firewood usage: late procurement timing relative to the begining of the heating season in a significant number of households, inadequate thermal insulation on heated buildings, and low efficiency of heating devices used in households. Therefore, it is necessary to take action to improve these three factors in the coming years to bring the state of firewood usage efficiency to a satisfactory level.

Experiences from implementing such activities in other regions of Serbia exist and can be implemented in the Vojvodina region with relatively little effort but with appropriate support from decision-makers.

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REFERENCES

1. Energy consumption in households in Republic of Serbia, Statistical office of the Republic of Serbia, Belgrade, 2021
2. Integrisani nacionalni energetski i klimatski plan republike Srbije za period do 2030. sa vizijom do 2050. godine (mre.gov.rs)
3. Glavonjić, B. (2011): **Consumption of wood fuels in households in Serbia - present state and possible contribution to the climate change mitigation,** Thermal Science, Vol. 15, No. 3, Vinča Institute of Nuclear Sciences, Belgrade, ISSN: 0354-9836, p. 571-585, DOI: 10.2289/TSCI1103571G.
4. Rule book on conditions, content and manner of issue certificate of energy properties building, Official Gazette of the Republic of Serbia No. 69/2012; available at: https://www.mgsi.gov.rs/sites/default/files/PRAVILNIK%20O%20USLOVIMA%20SADR%C5%BDINI%20I%20NA%C4%8CINU%20IZDAVANJA%20SERTIFIKATA%20O%20ENERGETSKIM%20SVOJSTVIMA%20ZGRADA.pdf
5. WISDOM SERBIA: Spatial wood fuels production and consumption analysis, FAO, Rome 2015, available at: http://www.fao.org/3/i4394e/i4394e.pdf

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DECARBONIZATION OF THE WOOD INDUSTRY IN BULGARIA WITH THE USE OF HYDROGEN TECHNOLOGIES, AND ACCORDING TO THE EUROPEAN GREEN DEAL

Dimitar Blagoev

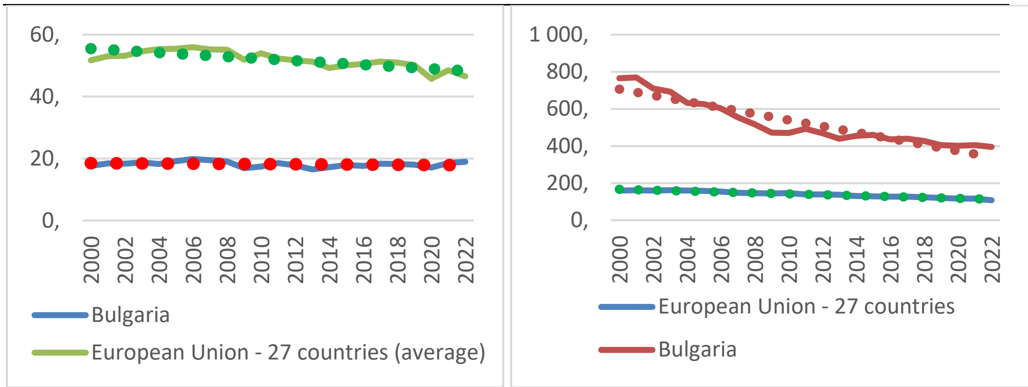
Abstract: This study aims to investigate the potential of the hydrogen technologies for application in the decarbonization of the wood industry, considering their economic efficiency. First part of the study estimates the energy consumption of the Bulgarian wood industry using statistical information for past periods. The second part analyses the existing hydrogen technologies with respect to their total efficiency and potential when applied for decarbonization of the wood industry. In the final part of the study we attempt to determine the most appropriate hydrogen technology that can be used for decarbonization of the wood industry in Bulgaria, based on its overall economic efficiency.
The object of the study is the Bulgarian wood industry, according to the Statistical classification of economic activities in the European Community (NACE), 2008.
The study examines particularly the innovation and investment aspects of the hydrogen technologies for decarbonization of the processes that are directly involved in the output of the companies of the Bulgarian wood industry, and can also be successfully managed. To achieve our goals we use statistical data, two-dimensional distributions and simulation of relevant economic functions.
Keywords: decarbonization, hydrogen technology, green deal, climate changes

1. ENERGY EFFICIENCY AND ENERGY INTENSITY OF THE BULGARIAN INDUSTRY (PARTICULARLY WOOD INDUSTRY)

Bulgarian industry has the highest energy intensity among all of the countries in the EU. The energy consumption related to the gross domestic product (GDP) per capita is almost three times higher than the average value for the EU. The carbon footprint of the entire Bulgarian economy is very alarming. It is approximately 4.3 times higher than the average value for the EU (*** The hydrogen future of Bulgaria, 2023, p. 9).

The energy intensity (or the total energy consumption) is an indicator of the Total energy balance, which is calculated in tons of oil equivalent (toe). This indicator measures the total energy consumption, excluding all of the energy carriers used for non-energy purposes (e.g. natural gas that is used for production of chemicals). The total energy consumption comprises only the energy, which is consumed by the end users (in this particular case the end users are represented by the companies in the wood industry). This excludes the energy consumption from the energy sector and the loses from the energy transfer and distribution (National Statistical Institute (NSI), Bulgaria, 2024).

Bulgarian economy has relatively low energy efficiency and, respectively, high energy intensity for generation of the GDP (Figure 1A and Figure 1B).



A) Energy efficiency (in million tonnes of oil equivalent primarry energy consumption)
B) Energy intensity of GDP in kilograms of oil equivalent per thousand euro

Figure 1. Energy efficiency and energy intensity of the Bulgarian economy
Source: Eurostat

Although during the last 23 years the average values of the energy efficiency tend to improve, i.e. the total energy consumption drops, Bulgaria shows quite steady energy consumption (Figure 1A). In this respect, the rise in the value of the GDP results in lower energy consumption per unit of GDP, but still Bulgaria has as much as twice energy intensity per unit GDP when compared to the average levels of EU (Figure 1B).

In the context of NACE, Bulgaria, 2008, the data for the energy intensity for the subsectors "Forestry" and "Production of wood materials, timbering without furniture production, cork production; production of straw materials and materials for knitting" are relatively constant, but still with a light trend for a decrease in the respective values (Figure 2). The steadiness of the energy consumption by the wood industry shows an alluring potential for implementation of innovative and energy saving technologies with minimized or eliminated carbon footprint. These technologies would lead to an increase in the energy efficiency and a decrease in the energy intensity, and the respective direct or indirect decrease in the wood industry contribution to the greenhouse gases generation.

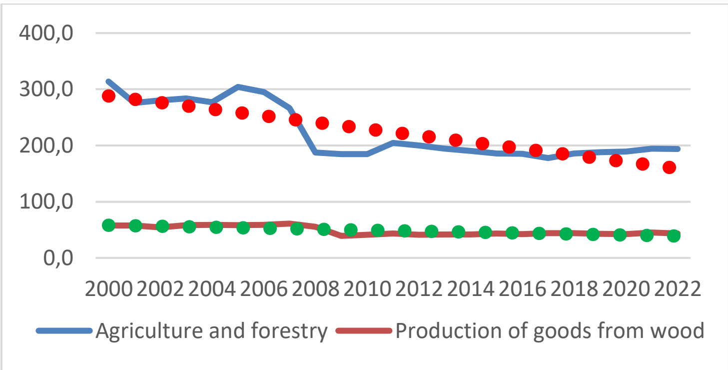


Figure 2. Total energy consumption in thousands of toe.
Source: NSI, Bulgaria. The data has been subjected to some recalculations.

2. HYDROGEN TECHNOLOGIES FOR DECARBONIZATION OF THE WOOD INDUSTRY

The use of hydrogen technologies in the European economy is recognized as a key factor for fulfilment of the ambitious goals of the European Green Deal. These technologies are ratified in the European Climate Law: decreasing net emissions of greenhouse gases in EU by 2030 with at least 55% from the levels in 1990, and achieving zero net emissions by 2050 (*** The European Climate Law). For achieving these goals in the “Strategy for hydrogen use for climate neutral Europe” (2020), there is planned huge transformation in all of the economy sectors, which is based on the production and consumption of hydrogen (***The hydrogen future of Bulgaria, 2023). The hydrogen can be used as a raw material, fuel, or accumulated energy carrier, and can be vastly utilized in the industry. It appears as important raw material for decarbonization of key industrial sectors of the economy.

Natural gas reforming is the main contemporary process for producing of hydrogen. This process is accompanied by production of carbon monoxide (CO) and eventually carbon dioxide (CO2). If the greenhouse gases are not captured in the process, the hydrogen is referred to as “grey hydrogen” (Hydrogen Europe, 2020). The hydrogen that is manufactured by natural gas reforming coupled with carbon capture and storage is called “blue hydrogen”. According to some sources, this is also the hydrogen that is produced by the electrolysis process, but with the use of energy from uncertified electric power systems. There are also “pink”, “yellow” and “green hydrogen”, the last being obtained via electrolysis, but with the use of energy form renewable energy sources and without greenhouse gas emissions (The hydrogen future of Bulgaria, 2023). The green hydrogen is the subject of the present investigation.

The additional decrees of the law for energetics (LE) give a definition for the notion “green hydrogen”, which states that this is hydrogen obtained via electrolysis or other methods that use renewable energy sources, e.g. biogas or biomethane (Law for energetics, 2024).

During the last two years there is an accent over the green hydrogen has been made in the European politics and funding programs.

3. TECHNICAL ASPECTS OF A HYDROGEN FACILITY FOR DECARBONIZATION

To fulfil the goals of the European Green Deal, hydrogen facilities can be built in order to assist in decarbonization of the activities of the companies from the wood industry in Bulgaria. These facilities are expected to support the achieving of much lower carbon footprint via generation and proper utilization of green hydrogen. The primary constituents of such hydrogen facility are structures that are intended for:

- Generation of green hydrogen – electrolysis module
- Storage of green hydrogen – special structures in the hydrogen facility
- Utilization of the green hydrogen for generation of electric power – installations for distribution of the electric energy
- Auxiliary facilities

3.1. Electrolysis module

The electrolysis of water is a process that uses electricity to decompose water by splitting it into hydrogen and oxygen. Here, we are focused on the use of proton exchange membrane (PEM) electrolyzer – an equivalent of “GINER S400”, 2.1 MW (Table 1).

Table 1. Main technical parameters of a PEM electrolyzer

Generation of hydrogen	400 Nm^3/h
Outlet pressure – nominal value	4.0MPa – maximum differential pressure of H_2 with respect to O_2
Purity	> 99.9%, Water vapor < 500 ppm N_2 < 2 ppm, O_2 < 1 ppm
Electric power	2.1 MW
Volume flow rate of chemically desalted water (deionized water) at maximum power	~ 0.8 m^3/h
Purity of chemically desalted water (deionized water)	minimum ASTM Type II; <1 μS/cm (>1 MΩ·cm); recommended ASTM Type I <0.1 μS/cm (>10 MΩ·cm)

3.2. Special structures in the hydrogen facility

The structures for storage of the hydrogen gas will be of capacity 20700 m3. For this purpose, we will need 14 horizontal reservoirs with storage capacity of 50 m3 and pressure of 4.0 MPa.

3.3. Utilization of the green hydrogen for generation of electric power

The generation of electric power from the hydrogen will be carried out in a module of a container type, an equivalent of "HYDROGENICS", 1MW (Table 2).

Table 2. Main technical parameters of a generator of an electricity generator

Output power	1 MW 380 V AC/50-60 Hz
Energy efficiency	>50 %
Fuel	Hydrogen >99.99 %
	Consumption 750 Nm^3/h per 1 MW
	Electric power for private needs – maximum of 40 KW
Released heat	Released heat <1.5 MW·h
	Temperature of the exhausted air - 70°C
Emissions	Noise level at a distance of 1 m – 75 dB
	Pollutants – zero emissions
Size and weight	Size – 2.9 x 2.4 x 12.2 m (84.9 m^3)
	Weight – 32000 kg

4. METHODOLOGY OF THE ANALYSIS AND ECONOMIC ASSESSMENT OF THE HYDROGEN UTILIZATION FOR DECARBONIZATION

The processes of analysis and economic assessment constitute of the following stages:

I. Calculation of the initial investments.
II. Design of the production schedule.

III. Calculation of the production expenses.

IV. Calculation of the income generated from sales of the electric energy that is not used for private consumption.

V. Calculation of the funds that are needed for building of the hydrogen facility.

VI. Calculation of the initial cash flow (investments).

VII. Calculation of the operating cash flow (net income).

VIII. Calculation of basic and additional financial indicators.

Main incoming resources

Electric power supply - 2.1 MW, power of the electrolyzers - 2 MW, volume of the stored hydrogen - 20 000 Nm3, economic life - 23 years (3 years for facility construction and 20 years for operation), cost of capital - 5%, selling price of the electric energy, generation of electric energy - 1 MW·h, initial investments, income from sales, etc.

Methods and indicators for analysis and assessment of the economic efficiency

1. NPV (Net Present Value); 2. ARR (Accounting Rate of Return); 3. ROI (Return on investment); 4. IRR (Internal Rate of Return)

According to us, these four indicators are sufficient and adequate for the economic assessment in our case. They reflect the specificity of the suggested investment, but also stick to the traditional approaches.

5. RESULTS AND DISCUSSION

Investment expenses for construction of hydrogen facility with power of 1MW will be 12 006 005 BGN

The benefits can be evaluated on the basis of the generated electricity per year and a forecast (based on analysis of retrospective data) for the average electricity price at the independent Bulgarian energy exchange. We can divide conditionally the 20 year period of operation into two subperiods – the first 10 year of operation, when the price of the electric energy would be 223 leva per MW·h, and a second subperiod of 10 years, when the price of the electric energy would be 253 leva per MW·h. In this way the forecasted income for the first subperiod will be 680 370 leva per year, and 770 880 leva per year for the second subperiod.

The funding is 12 006 005 leva and has a weighted average cost of capital 5%. It reflects both the minimum yield rate for the investors and the cost of the investment bank credits.

Financial indicators for assessment of the economic efficiency of the investment (Table 3).

Table 3. Value of main financial indicators

Indicator	Unit of measurement	Value
Net present value (NPV)	leva	1 146 812
Return on investment (ROI)	%	2.3
Accounting rate of return (ARR)	%	9.3
Internal rate of return (IRR)	%	9.0
Profitability index (PI)	number	1.5

6. CONCLUSIONS

From the calculated indicators for assessment of the economic efficiency we may conclude that the investment in the considered green hydrogen facility is economically expedient. Besides the economic efficiency, such investment would have environmentally friendly ecological effects. All of the calculated indicators have positive values.

All these results are based on the assumption that the electric energy, obtained from renewable energy sources (photovoltaic systems), and used to power the electrolyzers for the generation of green hydrogen, is of price 30 leva per MW·h during these 20 years. If the economic conditions appear to be different, the obtained results will be different too.

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REFERENCES

1. *** (2020). Strategy for hydrogen use for climate neutral Europe, European Commission, https://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:52020DC0301&from=BG
2. *** (2022). Assessment of the potential for development of hydrogen technologies in Bulgaria, Ministry of Innovation and growth of Bulgaria, https://www.mig.government.bg/wp-content/uploads/2023/03/oczenka-na-potencziala-za-razvitie-na-vodorodnite-tehnologii-v-republika-balgariya-2022.pdf
3. *** (2023). The hydrogen future of Bulgaria. National roadmap for improving of the potential for development of hydrogen technologies and mechanisms for hydrogen production and delivery, Ministry of Innovation and growth of Bulgaria, https://www.mig.government.bg/wp-content/uploads/2023/04/naczionalna-patna-karta-za-podobryavane-na-usloviyata-za-razgrasthane-na-potencziala-za-razvitie-na-vodorodnite-tehnologii-i-mehanizmite-za-proizvodstvo-i-dostavka-na-vodorod.pdf
4. *** The European Climate Law, https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_bg
5. Hydrogen Europe, 2020. Hydrogen Europe's Position Paper on the Sustainable and Smart Mobility Strategy. Brussels, https://hydrogeneurope.eu/position-papers/
6. Law for energetics (2024), https://lex.bg/bg/laws/ldoc/2135475623
7. NSI (2024). Methodological notes for determination of the total energy consumption by the industrial sectors, https://nsi.bg/sites/default/files/files/metadata/Energy-5.4.Methodology.pdf

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COMBINING THE FORESTRY AND AGRICULTURAL SECTORS BY USING PERMACULTURE AS A GOOD MEASURE TO COMBAT CLIMATE CHANGE

Gergana Slavova

Abstract: In recent decades, climate change at the global level has been unpredictable and very startling with the occurrence of severe droughts, hailstorms, floods, changing seasons and their characteristic temperature amplitudes. It is therefore logical to seek sound economic, social, natural and environmental solutions in this direction. Our view is that these several environments should be favourably combined by using permaculture and combining the agricultural and forestry sectors as an opportunity to counter global climate change in the world. Permaculture is the practical application of scientific ideas to the design of man-made natural habitats, especially flora and fauna, which, on the principle of agricultural systems, are as close as possible to the natural environment. The aim of this paper is to review the specialized Economic, Environmental literature in the field of permaculture application in the world and to propose adequate models for the development of agricultural activities combining the agricultural and forestry sectors in order to reduce the detrimental impact of climate change. To identify the ecological economic and social aspects. The methods used are of analysis, deduction induction, retrospection, comparative and contrastive method of analyzing the diffusion factors in introducing innovations in agrarian and forestry sector and using strategic analysis. The results obtained from the study can be successfully used by various agroforestry educational environmental social organizations as well as by farmers, scientists, researchers in the field of forestry and agricultural sector, agroforestry themselves and agrarian professionals.
Keywords: Permaculture, climate change, agriculture, forestry, Agricultural sector, climate change

1. LINKING CLIMATE CHANGE TO ENVIRONMENTAL PROTECTION AND PERMACULTURE CREATION

In recent years, serious environmental pollution on the one hand, and global warming on the other, have made it necessary to look for ways to tackle the problems associated with keeping the natural environment cleaner. Parallel to this, the trend towards an environmentally friendly agricultural economy has developed. As a consequence, there is a strong need to develop agroecology and to look for opportunities to develop diversified farming systems in the agricultural sector. Permaculture in turn is an international movement and system of ecological design(Bane,2012). It is "the deliberate design of landscapes by mimicking patterns and interactions found in nature"(Ewel,1999), while at the same time creating the opportunity to provide an abundance of food, fibre and energy to meet local needs" (Altieri, 2004) Through permaculture, models are designed and developed for direct application in the agricultural sector, emulating the living nature, making it possible to ensure the production of different crops in direct combination with different types of forest and field plants, and also in combination with different types of soils and soil fertility. As a consequence, a more sustainable agriculture based on integrated practices(Slavova,Stoilov, 2021), strategically sound decisions and better organic guidelines is being built (Bavec et all, 2009) Based on this sustainable agriculture, primary resources are being produced by the agricultural sector that can be used with success in light industry, in different directions. The forestry and agricultural sectors, as well as the international movement of resources and finished products, come together in this direction.

1.1. Development of permaculture in the modern world

The development of the permaculture society is supported by environmental and other nature-based organizations and institutes, as it is not only in line with the protection of the environment and nature in good condition, but is also an extremely good base for the production of natural raw materials for the food, forestry and light industries. There are several decisive and limiting factors in the presentation of permaculture as a major tool in the fight against climate change and the conservation of natural communities and agrarian farms as living functioning natural farms: first of all the many different definitions given by different researchers in the field of permaculture (Altieri and Toledo, 2011;Francis et all, 2011) Unfortunately, much of what has been written about permaculture as a solution to the problem has not been institutionalized in Europe and is based on real advances in practice that are isolated from research.(Bell, 2005) At the same time, however, the government of America expressed, through the Department of Agriculture has a department focused specifically on the development of agroforestry and the establishment of permaculture. Secondly, there is no complete systematic study of the origin of the idea and its application to permaculture construction and establishment, but it can serve with great success to reinvent traditional ecological knowledge and to make adaptive management decisions in real agribusiness.(Berkers et all, 2000). And permaculture in turn has a number of strengths and weaknesses in its application. It differs substantially from agroecology although it also has points of convergence with it.(Hobbs et all, 2011) In the late 20th century it was first defined as "an integrated, evolving system made up of perennial or self-perpetuating plant and animal species useful to humans.(Holzer, 2011) It was then first seen in more substantive terms, as a whole agricultural ecosystem of modelling based on existing simpler examples. Within just 10 years later, new definitions of permaculture emphasize the conscious design and maintenance of products in agriculture and in ecosystems that have a diverse, stable, sustainable and natural system.(Higgs, 2012) The emergence of ecological and plant biology protection, as well as alternative farming organisations, are giving a strong impetus to this global process. And also the construction of eco-routes and eco-villages and eco-communities promote significantly the development of permaculture. Thus, it is becoming a good alternative for organic food production, as well as products and resources for the production of clothing from natural materials and raw materials. Moreover, through it, the balance between humans and nature is brought back in a more easy and pleasant way. Permaculture is a way of thinking globally at a world level. It uses renewable energy sources and creates conditions for the use of natural energy. The main objective of permaculture is the understanding of the bioeconomy and environmental protection, as well as the return of the direct relationship between man and nature. Mollison and David Holmgren first mentioned that plants from different continents and communities can be present in the application of permaculture (Ferguson and Taylor, 2014). This is how most permaculture can be built in different countries. With climate change, it is now possible to sow much more heat-loving crops in our country, such as: pomegranates, kiwis, figs, olives, etc. In the northern countries, crops can be sown which used to thrive only in temperate continental climates. At this stage, the largest numbers of permaculture communities and organisations in the world are in America, China and England. If we analyze world agriculture today, we can find that the idea of permaculture coincides perfectly with the idea of developing sustainable agriculture (Gomez et all,2013). And sustainable agriculture is the right solution for climate change. This is achieved through a continuous farming process in which a second and a third crop are sown after the first crop and, in parallel, the co-development of these crops is combined with the cultivation of forest crops and the development of agroforestry. The combination of forestry with agroforestry was first proposed by Russell Smith in his work Tree Crops (Ferguson and Taylor, 2014). Permaculture combines extremely well with agroforestry and perennial cropping (DeHaan et all, 2005) , as well as with the design of using different agroforestry systems and applying mimicry and alleopathy between them. Mimicry is a form of natural protection consisting of imitation of natural processes in order to protect crop species and their survival, while aleopathy is the interaction between crop species of plants, herbs, spices and flowers in order to protect them from each other and from pests and diseases. Good examples of this are the use of aleopathic plants such as: basil sown next to tomatoes, tagetes sown in the vegetable garden or lettuces sown near vegetables to protect them from pests. When looking for mutual benefit in the different types of crops grown, we can easily find that tree crops stabilize the soil and give the crops grown with the permaculture method a chance to grow different agro-crops. In this way we can grow crops on different slopes, with different gradients, for example on hills and uneven surfaces.Permaculture, alongside agroecology, reflects the intersection of ecology and agricultural production in the world.

1.2. Key elements of permaculture

Agroecology and permaculture can develop in an uneven relativity and create the possibility of developing very good rural farms, especially under conditions of climate change, such as droughts and changing seasons. The agroecological literature analysing the development of agroecology and permaculture comes mainly from the USA and from Austria and the United Kingdom. The geographical distribution of permaculture began over time, precisely from these countries. The main elements of permaculture are represented by the following figure:

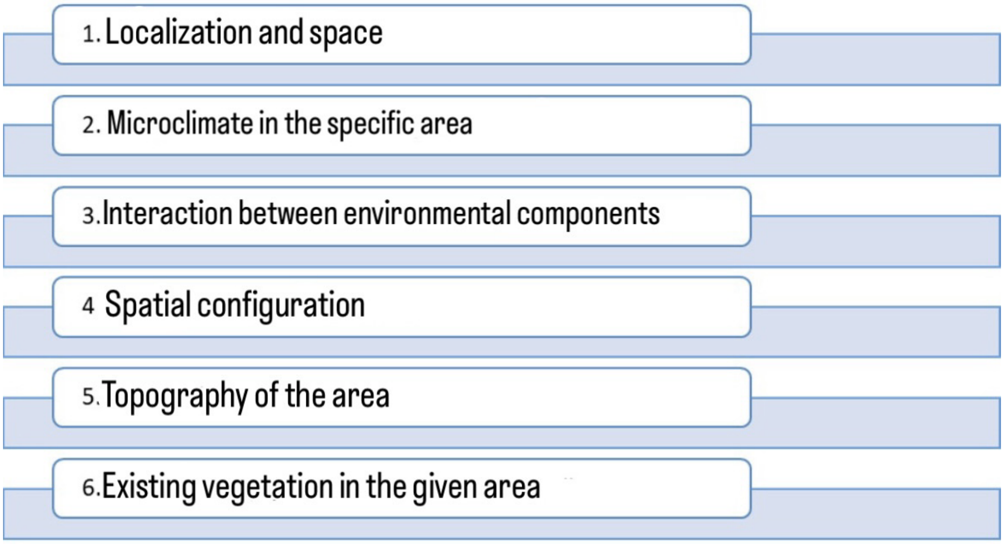

Fig. 1 Basic elements of permaculture, (based on Ferguson and Taylor,2014)

To these elements presented in Figure 1, in our opinion, two more main elements should be added: the good combination of all elements with the new climatic changes with and with the application of the possibility of combination with agroforestry.Thus, in our opinion, through the use of natural slopes and of woody vegetation, as well as of natural lakes and water sources, conditions are created for overcoming the microclimatic changes in a given area. Growing and combining different perennial crops in an area, e.g. cereals with tree crops, should lead to synergies between multiple crop growers on farms (Glover et al, 2010). On the basis of the ecological, economic and social components, good preconditions for permaculture development are created on the basis of the location and design tools of an agrarian production, as well as opportunities to overcome wind and soil erosion in the area. This can be achieved through the use of already existing or the creation of new forest belts or tree field barriers. The use of artificial canals linked to natural water sources for irrigation in turn leads to much better opportunities for overcoming climate change and also for establishing permaculture and developing agroforestry. Natural sources of light and energy, such as the sun, wind and water, can be used directly to build good permaculture communities. Through their proper use, not only global warming and climate change are overcome, but also serious natural and human cataclysms, such as: droughts, forest fires, hail, frost, glaciation, icing, floods and other adverse phenomena.(Bane, 2012) Very good solutions for overcoming some adverse cataclysms and global warming are not only the forest and field protection belts, but also the construction of dykes, fire channels, windbreaks, water channels for irrigation and others. All of these are very conducive to the use and construction of permaculture communities. And underlying all this is the concept of making good use of the landscape and the local varieties of crops grown, as well as their natural combination with other plants and animals, based on aleopathy. Through proper application and cultivation of permaculture, protection from wind erosion is achieved by creating forest and field belts, and also protection from water erosion by filtering and creating drains in the soil, as well as water channels to enable irrigation of plants during prolonged drought and high temperature amplitudes observed with climate change. Another very important strategic priority in being able to implement permaculture with the fight in climate change is the provision of different habitats for cultivated and native natural species. In direct correlation with this, proper crop rotation can be used, and also sowing more nitrogen fixing crops, such as legumes for example, which leave nitrogen in the soil and thus enrich it for the next crops grown.(Fujita,1992) Nature is the best teacher and this statement should never be forgotten. Thus, the home garden can become a good opportunity to create a permaculture environment, combining it with the natural landscape around. Wind erosion in the open plains at high wind speeds and its transition to storms can cause plants to be torn off, their roots to freeze and crops to be severely uprooted from the soil. And that is why we must act correctly and scientifically. For example, in Bulgaria, in the Dobrudzha region, good conditions are being created for overcoming wind erosion by creating forest belts. The forest plant species that are sown in them reduce the wind speed near the ground cover, the soil shaded by them in strong droughts has more fertile indicators. Importantly, the rate of drying of the surface soil layers is reduced and this is essential under climate change. The impact of woody and forest vegetation in such a permaculture community is also enormous. Forests and trees in these areas therefore protect against soil erosion to a much greater extent through their root system. Artificially created belts and forest stands are the main means of combating wind erosion, and they have been very successful in reducing the ground airflow from the leeward side.

2. CONCLUSIONS AND IMPLICATIONS

Agroecology and permaculture, in their symbiosis, are linked to supporting the cultivation of varieties that are resistant to climate change and promoting and reducing the use of chemical crop protection products and chemical fertilizers. By practising integrated agricultural and ecological production, the conservation of endangered indigenous varieties is a very important prerequisite for properly combating climate change and preserving indigenous varieties and traditional practices of sowing indigenous crop varieties typical of countries in the European Union. This process is also known as the process of maintaining specific habitats and restoring degraded soils and sites in areas across the European Union. Permaculture also combines well with organic plant breeding, leading to better opportunities for creating conditions for building agro-ecological communities and sustainable agriculture, as well as adaptive agrarian management towards maintaining a balance with nature. Parmaculture has made a huge contribution in creating projects for good agro-ecological transition. It combines integrated, adaptive and strategic management of the technologies applied, the crops grown, the water facilities used and protects the soil from soil and wind erosion, thus making it possible to configure all the agro-systems used.However, we should not forget that we are a fundamental part of nature and should not artificially distance ourselves from it.

REFERENCES

1. Altieri, M.A. (2004) *Linking ecologists and traditional farmers in the search for sustainable agriculture. Frontiers in Ecology and the Environment, 2 (1), 35-42*
2. Bane, P. (2012), *The permaculture handbook: garden farming for town and country. New Society Publishers*
3. Bavec, M., Malkar, S. G., Rozman, C., Pazek, K.,& Bavec, F.(2009).*Sustainable agriculture based on integrated and organic guidelines&understanding terms: The case of Slovenian development and strategy. Outlook on Agriculture,38 (1), 89-95*
4. Bell, G. (2005) *The permaculture garden. Publikations ecological economics,41 (1)*
5. Berkers, F., Colding, J.& Folke, C.(2000). *Rediscovery of traditional ecological knowledge as adaptive management. Ecology, 7 (1-2), p.55-63*
6. DeHaan, L., R., Van Tassel, D.L., &Cox T.S.(2005*) Perennial grain crops: A synthesis of ecology and plant breeding. Renewable Agriculture and Food Systems, 20 (1), 5-14*
7. Ewel, J.J.(1999) *Natural system as models for the design of sustainable systems of land use. Agroforestrry systems, 45 (1-3), 1-21*
8. Ferguson., Taylor, S.(2014) *Permaculture for agro ecology: design, movement, practice and worldview*
9. Francis, C. A. &Porter, P.(2011) *Ecology in sustainable agriculture praktikes and sustems. Critical reviews in plant sciences, 30 (1-2),64-73*
10. Fujita, K. Ofosu—Budu, K.G., & Ogata, S. (1992*) Biological nitrogen fixation in mixed legume-cereal cropping systems. Plant and soil, 141, 155-175*
11. Glover, J. D., Reganold, J.P., Bell, L.W., Borevitz, J., Brummer, E. C., Bukler, E.S., & Xu, Y.(2010). *Incresed food and ecosystem security via perennial grains. Science, 328 (59826), 1638-1639*
12. Gomez, L.F. Rios-Osorio,L. &Eschenhagen, M.L.(2013) *Agroecology publications and coloniality ofknoledge. Agronomy for sustainable development, 33, 355-362*
13. Hemenway, T. (2009*), Gaia's garden: a guide to home-scale permaculture. Chelsea Green publishing*
14. Higgs, E. (2012) *Changing nature:novel ecosystems, intervention, and knowing when to step back. Sustainability science: the emerging paradigm and the urban environment, 383-398*
15. Hobbs, R., J., Hallett, L.M., Ehrlich, P. R.,& Mooney, H.A. (2011) *Intervention ecology: applying ecological science in the twenty-first centry. BioScience, 61(6), 442-450*
16. Holzer, S. (2011) *Sepp Holzer's permaculture: a practical guide to small-scale, intergrative farming and gardening. Chelsea Green Publishing*
17. Slavova, G., Stoilov,D. (2021),*Sustainable development of family agricultural holdings through implementation of integrated plant protection, Agricultural University – Plovdiv, Scientific Works, vol. LXIII, book 1, 2021, Scientific Conference "The role of family business for sustainable development", p.26-33*

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ACCOUNTING AND REPORTING OF HARMFUL GREENHOUSE GAS EMISSIONS BY FOREST ENTERPRISES

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Abstract: Enterprises in the forest sector are specific types of entities in terms of greenhouse gas emissions. On the one hand, the regulations of the „Fit for 55" Package (2023) under the European Green Deal for Climate issues, primarily address the forestry enterprises' reporting in terms of their positions and commitment to reducing emissions and increasing absorption in the sector. This aspect is not new, dating back to the seventies of the 20th century. Mitigating global climate change through forestry was first proposed in 1970 (Dyson, 1977). However, in the late 1990s, this possibility was considered globally. The Kyoto Protocol (1997) included activities such as afforestation, reforestation, and measures to avoid deforestation as sources for protecting or enhancing greenhouse gas absorption. On the other hand, enterprises in the forest industry may generate emissions that are harmful to the climate (resulting from production, burning of forest biomass, forest degradation, etc.). This can lead such enterprises to potentially enter the market for emission allowances. In the Bulgarian accounting theory and practice the reporting of the previously outlined issues by forest enterprises has not been analyzed yet. Based on conducted studies, the authors of the paper attempt to determine the accounting objects related to the greenhouse gas emissions of the forestry and forest industry enterprises, as well as to propose models for their reporting.
Keywords: accounting, forest sector, greenhouse gas emissions, IFRS, national accounting standards

1. INTRODUCTION

The present report presents the results of scientific and applied research carried out by the authors regarding the possibilities for the accounting treatment of greenhouse gas emission quotas (GGE) as accounting objects and the peculiarities of their presentation in the financial statements of enterprises from the forestry-based sector. A specific point for the reporting units is that there are two significantly different aspects of their activity in the field of greenhouse gas emissions. On the one hand, the regulations from the "Prepared for Goal 55" Package (2023) of the European Green Pact, Regulation (EU) 2018/841 of the European Parliament, CLIMAFORCEELIFE and other international organizations (CITEPA, FAO, FCP, etc.) for the climate treat the activity of the reporting units mainly from their positions and commitment to reducing emissions and increasing absorption in the sector. On the other hand, forestry industry enterprises can generate emissions harmful to the country's climate (from production, burning of forest biomass, forest degradation, etc.), and potentially enter the market for emission allowances. The problem of these two different aspects of the activity of the accounting units of the sector is unexplored at the national level from the perspective of accounting theory and practice. The authors identified another relevant problem in the field of reporting, namely, one part of the enterprises are from the non-financial sector, and another part are from the public (state or municipal) sector. For non-financial sector enterprises, two accounting bases are applicable, according to the current legislation - national accounting standards (NAS) and international accounting standards (IAS). New objects and new reporting models can be introduced into them. For public sector enterprises, only the so-called budget accounting is applicable, which is regulated by law, whereas the introduction of new objects and reporting models is highly limited. The presence of significant differences in the organization of the reporting process significantly hampers the development of a unified model of accounting presentation.

Research Methods. The methods used in this report are of general significance and traditionally applicable, which are: historical and logical method, comparative method, method of observation and monitoring, and regulatory approach.

Research thesis (assumption). There is a deficiency in the national accounting regulatory, theoretical and applied framework regarding the differentiation of the two aspects of GGE in the activity of forestry-based sector reporting units, as a result of which they are not adequately presented in their annual financial statements (AFS) and their non-financial declarations. The authors make an attempt to present solutions to the investigated problems by proposing models for accounting presentation of both aspects. The models were also developed in the context of the two reporting standards IFRS S1 and IFRS S2 issued in June 2023 by the International Sustainability Standards Board (ISSB) (Bacheva, S., Pozharevska, R. 2023).

2. LITERATURE REVIEW

At the national level, it was not until the the 1990s that the so-called "environmental accounting" emerged. In the period up to 2015, ambiguities were observed, both in terms of the identification of new accounting objects, and in terms of the regulatory and methodological framework of their presentation for accounting purposes (Pozharevska, R., 2017). In 2016, the national regulatory accounting system took a step in the direction of responding to current processes, including topics such as ecology and social capital. Chapter Seven "Annual Activity Report", Section III of the current Accounting Law includes requirements for the presentation in the non-financial statement of some basic parameters related to ecology: to contain a description of the policies, activities and results of enterprises in relation to their activities, carried out in the field of ecology; to include the objectives, risks and upcoming tasks with regard to environmental policies; to contain a description of the main indicators for the results of the activities related to environmental issues. The question is to what extent only the disclosure of this information can provide an answer about the specific processes taking place in the enterprises of the forestry-based sector in relation to GGE.

In the course of their research, the authors examined the specialized accounting literature on the issue at the national level. This literature turned out to be quite limited. The main publications are on the issues of financial statements and audit of the activities of enterprises from the forestry-based industry (Ventsislavova Georgieva, D., Bankova, D., 2020,2022, 2023).

In terms of reporting for public sector enterprises, only a highly regulated organization of accounting is applicable, whereas the international public sector accounting standards (IPSAS) are not applied in the country. Budgetary enterprises apply in practice the NAS canceled in 2004, in compliance with the directive of the Ministry of Finance VAT 20. Regardless of the numerous studies and publications of leading specialists in this field and their call for the introduction of the IASPS in the country, the situation to date remains unchanged (Feschiyan, D., 2023; Feschiyan, D., Andasarova R. ,2023; Feschiyan, D., Savova, K., Andasarova R., 2021).

A number of international publications and practices related to the measurement and accounting of emission allowances were also studied, with a view to adapting them to national practice and theory (Autorite des normes comptables, 2012,2015; Poulet, S.,2021; Cour des comptes européenne, 2020).

3. MODELS FOR PRESENTING THE TWO ASPECTS OF GGE IN FORESTRY-BASED SECTOR COMPANIES

3.1. Specificities of GGE quotas as objects of accounting presentation

The GGE models developed by the authors are based on the conducted research and are limited only to the enterprises from the non-financial sector, since the absence of an appropriate accounting conceptual framework for the public sector in Bulgaria makes it difficult to model both aspects of the reporting process. What both models have in common is that the disclosure in the non-financial statement to the AFS of the policies, actions and results in the field of ecology has not been dropped.

At the moment, enterprises from the forestry-based sector are not obliged to purchase or have allowances for greenhouse emissions. However, the authors are of the opinion that the use of quotas should be imposed for productions and activities that emit harmful emissions.

The complexity of determining emission allowances for accounting purposes is observed both internationally and nationally. On the one hand, the fact is proven by the short life of IFRIC 3 "Emission Rights", adopted by the IASB in December 2004, canceled on 01.07.2005 and without an analogue to date. At the national level, the accounting and tax regulation of emissions quotas is treated only in the Opinion of the Ministry of Finance regarding the National Plan for the allocation of quotas for trading in greenhouse gas emissions for the period 2008-2012. In both documents, the prevailing opinion is that GGE allowances should be recognized as intangible assets (Pozharevska, R., 2018).

However, practice and theory over the last decade have imposed another paradigm, to which the authors subscribe, namely that allowances cannot be recognized as intangible assets because they are not, by their very nature, a right to emit, but an instrument to repay an obligation, incurred as a result of the emissions made. Furthermore, they do not meet the threshold criteria for realizing an economic benefit and the asset being of essential use in generating those benefits. GGE quotas should be treated as a new, unique "raw material". They are not strictly physical stocks of raw materials. Although their purchase is necessary for the production activity, they are not physically involved in the production process, but only virtually.

Adopting this principled understanding leads to a significant problem for reporting entities that apply the NAS. In contrast to the provisions of IAS 2 "Inventories", item 2 of IAS 2 "Accounting for inventories" requires that the asset should be tangible in order to fall within the scope of the standard, which as a result leads to the impossibility of accounting of quotas. There are two options before the national theory and practice in order to be able to adequately account for these specific resources. Either to update item 2 of NAS 2 "Inventories" by dropping the limitation for inventories to recognize only material resources. Or to develop an independent new accounting standard for the accounting presentation of GGE quotas.

3.2. Model of accounting presentation of the use of GGE allowances

The proposed model for the accounting presentation of GGE allowances in the forestry-based sector is adapted from the most common accounting presentation proposals in this controversial accounting object. GG-emitting enterprises face a new production cost, in line with the polluter-pays principle. The emission does not lead to direct payments to the state, in the form of taxes, but to the obligation to purchase and to restitution of quotas to the state. By their very nature, GGE allowances should be presented as two different accounting entities depending on whether businesses generate GGE or sell GGE allowances. For GG-emitting enterprises, they should be a specific new type of raw material stock without physical form. For quota traders, these should be represented as specific goods in virtual form. In both cases, it is necessary that the applicable accounting standard does not have a materiality requirement for its current stocks.

3.3. Model of accounting presentation of the activities to reduce emissions and increase absorption of harmful emissions by the sector

The authors believe that this model should cover two levels of presentation:

- mandatory accrual of provisions for recultivation by all enterprises from the forestry-based sector, calculated on the basis of generated GGE in a retrospective aspect of several years or determined by law;
- recognition of new "virtual production" generated as a result of reducing emissions and increasing absorption of harmful emissions - the problems in this direction are related to the reliable assessment of this "production" and the development of a methodology for its accounting recognition and possible "sales" of quotas for enterprises generating harmful GGEs, regardless of the sector of activity.

4. CONCLUSIONS

In the presented report, the authors made an attempt to identify the main problem areas regarding the accounting presentation of GGE in enterprises from the forestry-based sector. They proposed basic models for optimizing information in the AFS of forest enterprises from the non-financial sector. The models could also be adapted for enterprises from the public forestry-based sector if there is an appropriate regulatory framework for this. The authors are well aware that the results of their research revealed in this report are only the first step in clarifying the issue and will continue the search for solutions for the theory and practice of presenting greenhouse gas emissions in the forestry-based sector.

REFERENCES

1. Bacheva, S., Pozharevska,R. (2023): Opovestiavane na informatzia za ustoichivost vav finansovite otcheti – regulatzii i problemi. Nautcni troudove na UNSS (5): pp. 11-31. ISSN: 0861-9344;ISSN (online): 2534-8957;UNWE, Sofia. URL: http://unwe-research -papers.org/

2. Ventsislavova Georgieva, D., Bankova, D. (2023): The role of the financial auditor for the participation of forestry enterprises in global value chains, Current trends and challenges for forest-based sector: carbon neutrality and bioeconomy, Proceedings of Scientific Papers, WoodEMA, i.a., Czech University of Life Sciences Prague, pp. 65-68, ISBN: 978-953-8446-01-6
3. Ventsislavova Georgieva, D., Bankova, D. (2022): Hybrid audit as an innovative approach in the audit practice of forestry. 15th International Scientific Conference WoodEMA 2022 Crisis management and safety foresight in forest-based sector and SMEs operating in the global environment, International Association for Economics, Management, Marketing, Quality and Huma Resources in Forestry and Forest Based Industry – WoodEMA, i.a., Slovak Association for Quality. pp. 31-36, ISBN: 978-953-8446-00-9
4. Ventsislavova Georgieva, D., Bankova, D. (2020): Problems in audit and reporting in Bulgaria's forestry. Conference: Sustainability of forest-based industries in the global economy, Proceedings of scientific papers At: Croatia pp. 31-36, ISBN: 978-953-57882-8-5
5. Feschiyan, D. (2023): Za neobhodimosta ot standartizirani finansovi otcheti v publichnia sektor. Spisanie IDES, br.2, pp.1-25. Sofia, Bulgaria
URL:https://www.ides.bg/%D0%B5%D1%81%D0%BF%D0%B8%D1%81%D0%B0%D0%BD%D0%B8%D0%B5/2023/%D0%B1%D1%80%D0%BE%D0%B9-2/
6. Feschiyan, D., Andasarova R. (2023): Financial Reporting in the Public Sector in the Republic of Bulgaria under the Conditions of European Harmonizati. Economics, Management & Business 2023: Contemporary Issues, Insights and New Challenges. Presov University Press, University of University of Presov, Slovakia. pp. 719-725
7. Feschiyan, D., Savova, K., Andasarova R. (2021): Kontzeptualnata ramka za finansovo otchtitane v publichnia sektor – predizivikatelstvo pred finansovata otchetnost bv publichnia sektor na Bulgaria. Spisanie IDES, br.4, pp.1-20. Sofia, Bulgaria
URL:https://www.ides.bg/%D0%B5%D1%81%D0%BF%D0%B8%D1%81%D0%B0%D0%BD%D0%B8%D0%B5/2021/%D0%B1%D1%80%D0%BE%D0%B9-4/
8. Poulet, S. (2021): Contribution de l'élevage et des émissions de gaz à effet de serre indirectes au bilan carbone du secteur agricole de l'île de La Réunion en 2018. Amélioration des plantes. 2021. dumas03667163
URL: https://dumas.ccsd.cnrs.fr/dumas-03667163
9. Pozharevska, R. (2018). Accounting aspects of intellectual capital. IC of UNWE, Sofia
10. Pozharevska, R. (2017): Accounting Aspects of Greenhouse Gas Emission Allowances /current issues in theory and practice in the Republic of Bulgaria/. Колективна научна публикация на ФСФ при УНСС и на Lodz University of Technology, Poland на тема: „Contemporary Issues of Accounting and Management in Poland and in Bulgaria"; Lodz University of Technology Press; ISBN 978-83-7283-834-6; pp.150-166
11. ***: Autorite des normes comptables. Propositions de comptabilisation des quautas d'emissions des CO 2.
URL:https://www.anc.gouv.fr/files/live/sites/anc/files/contributed/ANC/3_Recherche/D_Propositions/2012/Livre%20de%20proposition_Comptabilisation%20des%20quotas%20CO2_FRANCAIS.pdf
12. ***: CITEPA (2013): Emissions de gaz à effet de serre du secteur de l'agriculture, de la forêt et des autres utilisations des terres (AFOLU) (1961-2010). Base de données élaborée par l'Organisation des Nations Unies pour l'agriculture et l'alimentation (FAO) Données publiées le 12 février 2013.
URL:https://www.citepa.org/wpcontent/uploads/veille/CITEPA_INT_AFOLU_Connaissances_FAO_EmissionsGES_120213.pdf
13. ***: Cour des comptes européenne (2020): Le système d'échange de quotas d'émission de l'UE: l'allocation de quotas à titre gratuit devrait être mieux ciblée, #chapter7spécial de la Cour

des comptes européenne présenté en vertu de l'article 287, paragraphe 4, deuxième alinéa, du TFU
URL:https://op.europa.eu/webpub/eca/special-reports/emissions-trading-system-18 2020/fr/

14. ***: International Financial Reporting Standards Foundation, URL: https://www.ifrs.org/groups/international-sustainability-standards-board/
15. ***: Forest Carbon Partnership (2021): Note d'orientation pour la comptabilisation des émissions/absorptions héritées. URL:https://www.forestcarbonpartnership.org/system/files/documents/fmt_note_20205_application_of_ipcc_guidelines_v2_fr_.pdf
16. ***: FAO, URL: https://www.fao.org/3/y0900f/y0900f06.htm
17. ***: Fit for 55. The European climate law makes reaching the EU's climate goal of reducing EU emissions by at least 55% by 2030 a legal obligation. EU countries are working on new legislation to achieve this goal and make the EU climate-neutral by 2050. URL: https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/
18. ***: Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU URL: https://eur-lex.europa.eu/eli/reg/2018/841/oj?locale=en
19. ***: The CLIMAFORCEELIFE (LIFE19 CCA/SK/001276) project received funding from the LIFE Climate Action sub-programme of the European Union. URL: https://clima4ceelife.eu/
20. ***: https://www.wwf.bg/?2166941/wwf-inteligentno-upravlenie-na-gorite-v-usloviyata-na-klimatichni-promenii
21. ***: Zakon za schetovodstvo. URL: http://top-account.net/zakoni/138-zakon-za-schetovodstvoto.html

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SUSTAINABILITY REPORTING ON CLIMATE CHANGE IN THE FORESTRY-BASED INDUSTRY

Atanas Atanasov, Rumyana Marinova

Abstract: In recent years, sustainability reporting in the forestry-based industry has gained significant attention, particularly with regard to climate change. Our study synthesizes current research to provide insights into the key themes surrounding sustainability reporting practices specific to climate change mitigation and adaptation in the forestry-based industry. Based on recent publications that explore climate change-related risks and opportunities in the forest industry, our study provides insight into how sustainability reporting can be useful in addressing climate-related risks by providing structured financial and non-financial information about enterprises in the forest sector to different stakeholders.
The identified challenges and future directions offer valuable insights for researchers, policymakers, and practitioners working towards a more sustainable and resilient forestry sector in the face of climate change.
Keywords: sustainability reporting, forest-based industry, climate change, risks, sustainability standards

1. INTRODUCTION

Sustainability reporting on climate change in the forestry-based industry is a critical aspect of addressing environmental challenges and ensuring the long-term viability of forest resources. The forestry sector plays a pivotal role in sustainable development, particularly in the urgent context of mitigating climate change (Martinho & Ferreira, 2020). Climate change impacts are not only limited to environmental aspects but also have socio-economic implications, such as community development and rural livelihoods.

The answer to all contemporary challenges lies in providing adequate information on sustainability in forest-based industry enterprises through the application of sustainability reporting. In light of the growing focus on sustainability, there is a need for improved reporting mechanisms to assess the impacts of forestry activities on climate change and the reverse impacts as well.

The importance of forestry-based industry in the EU can be summarized in numbers from CEPI's report: 420 000 enterprises with a total turnover of over 520 billion euros (around 18 % of the bioeconomy), around 3.5 million workers, 143 billion euros each year added value to the economy of European Union (CEPI, 2019).

The aim of this study is based on recent publications that explore climate change-related risks and opportunities in the forest industry to provide insights into the key themes of sustainability reporting practices specific to climate change mitigation and its adaptation in the forestry-based industry. The main thesis we share is that the definition of common indicators for all enterprises and specific sustainability indicators (KPI) in different sectors makes it possible to establish comparability of the reported information and opportunities for making management decisions at the company and national level.

The study focuses mainly on the applicability of legislation in the European Union regarding the reporting of climate-related risks and its application in forestry-based enterprises.

2. CLIMATE CHANGE-RELATED RISKS IN FORESTRY-BASED INDUSTRY

According to a report by the European Forest Institute forests and timber commodities form an integral part of the Land Use, Land-Use Change, and Forestry (LULUCF) sector, a sector within the EU that eliminates around 10% of the total greenhouse gas emissions of the European Union, which currently stand at 256 MtCO2eq/year. The sector is required to eliminate an additional 50 MtCO2eq/year by 2030 and 170 MtCO2eq/year by 2050, as per the policy targets proposed by the European Commission (Verkerk et al., 2022). The analysis in the study indicates that the combined additional mitigation potential achievable by avoiding deforestation, afforestation/reforestation, altering wood utilization, and cascading could reach up to 72 MtCO2eq/year by 2050 in the EU (Verkerk et al., 2022). At the same time, the CEPI's study indicates that the EU's sustainably managed forests produce today an overall climate mitigation impact amounting to 13 % of European greenhouse gas emissions (CEPI, 2019). According to World Bank Report for 2023 deforestation remains a key source of GHG emissions. Countries included in this report cover 56 percent of the world's tropical forest area and 48 percent of global emissions connected to forest loss. (World Bank Group, 2023).

Forestry-based industries are indeed facing significant climate change-related risks that can impact their operations and sustainability. According to Andersson et al. climate change can lead to various challenges such as changes in forest composition, increased frequency of extreme weather events like storms and wind throw, and alterations in the geographic distribution of tree species (Andersson et al., 2018). These risks are not uniform and can vary by region, with specific geographic areas experiencing different effects of climate change on forestry (Mozgeris et al., 2019).

Adapting to climate change in forestry requires a multifaceted approach that considers both risks and opportunities created by climate change. Furthermore, the forestry industry must focus on sustainable forest management practices that take into account the ecological impacts of climate change and incorporate additional complexities for managers (Álvarez-Miranda et al., 2019). In light of these challenges, there is a growing recognition of the need for enhanced reporting of climate change adaptation in the forestry sector. This includes developing sector-specific sustainability reporting standards and their adoption not only for large public enterprises but for small enterprises too. It is critically important because there is a consensus on the importance of forestry in mitigating climate change through practices like forest carbon sequestration, which can have a significant impact on reducing greenhouse gas emissions.

According to "EU Forest-Based Industries 2050" (CEPI, 2019) mitigation strategies within the forestry sector encompass the prolongation of carbon sequestration in harvested wood products, the practice of product substitution, and the cultivation of biomass for bio-energy purposes. The report indicates that the European forests and the forest-based sector provide integrated solutions to the global climate challenge on a very large scale. The overall and positive climate effect is estimated at -806 million tons of carbon dioxide equivalents annually. This corresponds to c. 20 % of all fossil emissions in the European Union (CEPI, 2019).

Overall, the forestry-based industry faces a range of climate change-related risks that necessitate proactive adaptation strategies, sustainable management practices, and a deeper understanding of the complex interactions between climate change and forestry ecosystems. All the incentives for climate-related risks mitigation need real-time, adequate and financial-related sustainability information using sustainability reporting.

3. SUSTAINABILITY REPORTING FOR CLIMATE-RELATED RISKS IN FORESTRY-BASED INDUSTRY

Climate change presents significant risks to the forestry-based industry, affecting various aspects of sustainability reporting. Challenges faced by the forestry sector include biodiversity loss, extreme weather events, and the necessity for adaptation due to climate change (Perunová & Zimmermannová, 2022). The implementation of sustainability reporting in small and medium enterprises is important because, as Mikkila & Toppinen remarked, the social and environmental reporting in large companies is more institutionalized with little flexibility for company-specific diversification in reporting (Mikkila & Toppinen, 2008).

At the European Union level, the maintenance of sustainability standards (including limits, methodologies, and thresholds is extensively applied to various countries and regions with diverse levels of representation, aiming to advance the socio-economic roles of forests within the EU (Pecurul-Botines et al., 2023). This effort is guided by the new EU Forest Strategy, which primarily aligns with the objectives outlined in the European Green Deal.

In April 2021, the Sustainable Finance Package was embraced by the European Union with a primary emphasis on bolstering private investments geared towards fostering a climate-resilient economy. This comprehensive package encompasses a proposition for the Corporate Sustainability Reporting Directive (CSRD). As a part of the Green Deal in EU Corporate Sustainability Reporting Directive (CSRD) and related European Sustainability Reporting Standards (ESRS) have a key role in providing information on sustainability issues that is comparable, verifiable, timely and tied to the company's financial performance. According to the rules of the Directive, companies are mandated to provide in-depth and comprehensive disclosures on sustainability performance and the strategic implications involved.

According to the Directive, firms are obligated to evaluate the significance of sustainability issues throughout their value chains and determine which of over 1,000 data points should be revealed. Additionally, disclosures will include qualitative data, such as how corporate strategies address sustainability risks and opportunities. All disclosed information must undergo independent assurance, commencing at a limited level and become reasonable in the future.

The European Sustainability Reporting Standards (ESRS) dictate the disclosures that companies must make. These standards, specific to sustainability reporting within the EU, encompass a wide range of environmental, social, and governance (ESG) topics, such as climate change, biodiversity, and human rights. ESRS aim to facilitate a clear and coherent structure for sustainability information that will be reportable in the sustainability report of the company.

Companies are required to disclose information regarding the business model and strategy with addressing risks linked to sustainability issues, as well as the strategies in place to steer the company toward a sustainable economy and in alignment with the Paris Agreement's objective of limiting global warming to 1.5 °C. This includes the commitment to achieving climate neutrality by 2050. Moreover, companies must provide details on the set targets associated with sustainability concerns, including specific deadlines for their accomplishment such as GHG emissions reduction targets for 2030 and 2050. Furthermore, they should report on the progress made towards these targets and indicate whether their environmental objectives are founded on scientific evidence.

The main requirements for reporting climate change–related risks and information are described in ESRS E1 – *Climate Change*. This standard will be mandatory for all forestry-based enterprises within the scope of the Directive. ESRS E1 is one of the topical standards that aims to specify Disclosure Requirements that will enable users of sustainability statements to understand (ESRS E1, 2023):

- how the undertaking affects climate change, in terms of material positive and negative actual and potential impacts
- the undertaking's past, current, and future mitigation efforts in line with the Paris Agreement (or an updated international agreement on climate change) and limiting global warming to 1.5°C;
- the plans and capacity of the undertaking to adapt its strategy business model(s) and in line with the transition to a sustainable economy and to contribute to limiting global warming to 1.5°C;
- any other actions taken by the undertaking, and the result of such actions to prevent, mitigate or remediate actual or potential negative impacts
- the nature, type and extent of the undertaking's material risks and opportunities arising from the undertaking's impacts and dependencies on climate change, and how the undertaking manages them
- the financial effects on the undertaking over the short, medium and long-term time horizons of risks and opportunities arising from the undertaking's impacts and dependencies on climate change.

ESRS E1 also formulates 9 distinct disclosure requirements which makes this standard highly structured (from E 1-1 to E 1-9). All these requirements are divided into three main groups: Strategy (E1-1), Impact, risk and opportunity management (E1-2, E1-3) and Metrics and targets (E1-4 to E 1-9). Based on the information above and because the CSRD is one of the elements of the European Green Deal, which aims to make the European Union carbon neutral by 2050, and to keep global warming to 1.5 degrees, in line with the objectives of the Paris Agreement, we share the view that ESRS E1 probably will be the standard on which the greatest efforts will be focused. This standard is "special" because if the company determines that reporting on ESRS E1 is unnecessary, a comprehensive and well-reasoned justification must be presented, along with an examination of potential future circumstances that may warrant the topic being deemed "material".

Each Disclosure Requirement is linked to an Application Requirement, particularly in the case of ESRS E1. These specifications outline in great detail the necessary responses that companies must provide to the various inquiries presented to them. When addressing the accountability of their greenhouse gas (GHG) emissions, companies are obligated to adhere to the methodology established by the GHG Protocol and gather data on the scope 1, 2, and 3 aspects of their operations. As previously mentioned, the computation of emissions pertains to their entire value chain. This can prove to be a considerably intricate task, necessitating the involvement of numerous stakeholders, ranging from employees to suppliers and service providers.

In addition to merely assessing GHG emission levels and the environmental impact of their operations, forestry-based organizations must also incorporate this data into their corporate strategies. Within section E 1-3 of ESRS E1, companies are expected to elaborate on each action taken throughout the year to mitigate and/or adapt to climate change, along with the achieved outcomes and anticipated results. Specifically, this report should encompass all initiatives aimed at climate change mitigation through decarbonization and efforts to diminish GHG emissions.

Moreover, in section E 1-4, companies should outline all actions taken during the year to address climate change, as well as the accomplished results and expected outcomes. Particularly, this presentation should encompass all strategies related to climate change mitigation through decarbonization and measures to reduce GHG emissions.

For the most part, climate-related risks have their financial dimensions in company reports. The E 1-9 Disclosure Requirement of ESRS E1 focuses entirely on evaluating the projected financial impacts (risks and/or opportunities) of climate change and the execution of a transition plan. This evaluation demands the full integration of climate considerations into corporate strategies. Companies must demonstrate their anticipation of the impacts of climate change on their operations and the measures taken to address them.

Incorporating measures to reduce their environmental footprint must also be a part of this strategic approach. Consequently, forestry-based companies will need to establish GHG emission reduction targets aligned with the objectives of the Paris Agreements, which seek to limit global warming to 1.5˚C, and the European goal of achieving carbon neutrality by 2050.

4. CONCLUSION

Sustainability reporting on climate-related risks is essential for improving decision-making processes within organizations. We support the view that integrating climate risk disclosures into sustainability reports enhances environmental accountability and transparency. These disclosures offer valuable information on both mitigating and adapting to climate risks, enabling stakeholders to make well-informed decisions. The increasing recognition of climate change among various stakeholders motivates corporations to improve transparency in sustainability data, assess operational efficiency, and enhance environmental, social, and governance practices.

By redefining the materiality concept to include climate-related risks, utilizing decision-support tools, and integrating sustainability indicators, forestry-based companies can make informed decisions that contribute to sustainable development goals. The challenges that have been identified and the future directions that have been outlined provide valuable perspectives for researchers, policymakers, and practitioners who are dedicated to advancing the forestry sector that is both sustainable and resilient amidst the challenges posed by climate change.

REFERENCES

1. Álvarez-Miranda, E., Garcia-Gonzalo, J., Pais, C., & Weintraub, A. (2019). A multicriteria stochastic optimization framework for sustainable forest decision making under uncertainty. Forest Policy and Economics, 103, 112-122. https://doi.org/10.1016/j.forpol.2018.03.006

2. Álvarez-Miranda, E., Garcia-Gonzalo, J., Pais, C., & Weintraub, A. (2019). A multicriteria stochastic optimization framework for sustainable forest decision making under uncertainty. Forest Policy and Economics, 103, 112-122. https://doi.org/10.1016/j.forpol.2018.03.006
3. Andersson, E., Keskitalo, E., & Bergstén, S. (2018). In the eye of the storm: adaptation logics of forest owners in management and planning in Swedish areas. Scandinavian Journal of Forest Research, 33(8), 800-808. https://doi.org/10.1080/02827581.2018.1494305
4. CEPI. (2019, 11). https://www.cepi.org/wp-content/uploads/2020/06/Cepi-Climate-effects-of-the-forest-based-sector-in-the-EU_Exc-summary.pdf. Retrieved from CEPI: https://www.cepi.org/wp-content/uploads/2020/06/Cepi-Climate-effects-of-the-forest-based-sector-in-the-EU_Exc-summary.pdf
5. ESRS E1. (2023). ESRS E1 Climate Change. Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards. OJ L, 2023/2772, 22.12.2023. EC. Retrieved from http://data.europa.eu/eli/reg_del/2023/2772/oj
6. Martinho, V. J. P. D. and Ferreira, A. J. D. (2020). Forest Resources Management and Sustainability: The Specific Case of European Union Countries. Sustainability, 13(1), 58. https://doi.org/10.3390/su13010058
7. Mikkilä, M. and Toppinen, A. (2008). Corporate responsibility reporting by large pulp and paper companies. Forest Policy and Economics, 10(7-8), 500-506. https://doi.org/10.1016/j.forpol.2008.05.002
8. Mozgeris, G., Brukas, V., Pivoriūnas, N., Činga, G., Makrickiene, E., Byčenkienė, S., … & Augustaitis, A. (2019). Spatial pattern of climate change effects on Lithuanian forestry. Forests, 10(9), 809. https://doi.org/10.3390/f10090809
9. Pecurul-Botines, M., Secco, L., Bouriaud, L., Giurca, A., Brockhaus, M., Brukas, V., Hoogstra-Klein, M.A., Konczal, A., Marcinekova, L., Niedzialkowski, K., Øistad , K., Pezdevšek Malovrh, Š., Pietarinen, N., Roux, J-L., Wolfslehner, B., Winkel, G. 2023. Meeting the European Union's Forest Strategy goals: A comparative European assessment. From Science to Policy 15. European Forest Institute. https://doi.org/10.36333/fs15
10. Perunová, M. and Zimmermannová, J. (2022). Analysis of forestry employment within the bioeconomy labor market in the Czech Republic. Journal of Forest Science, 68(10), 385-394. https://doi.org/10.17221/84/2022-jfs
11. Verkerk, P.J., Delacote, P., Hurmekoski, E., Kunttu, J., Matthews, R., Mäkipää, R., Mosley, F., Perugini, L., Reyer, C. P. O., Roe, S., Trømborg, E. 2022. Forest-based climate change mitigation and adaptation in Europe. From Science to Policy 14. European Forest Institute. https://doi.org/10.36333/fs14
12. World Bank Group. (2023). The Development, Climate, and Nature Crisis: Solutions to End Poverty on a Livable Planet. Washington: The World Bank Group.

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SUSTAINABILITY DISCLOSURES IN FOREST-BASED SECTOR IN BULGARIA

Ali Veysel

Abstract: The report examines sustainability disclosures by the state enterprises in the forest-based sector in Bulgaria. The theoretical concept and the legal requirements in this regard are presented. The changes that will be made are described. Financial statements, annual management reports, non-financial statements, and auditor`s reports of the enterprises for 2022, compiled according to the Bulgarian Accounting Act and published in the Commercial Register, are analyzed. On this basis, conclusions are made about the problems in sustainability disclosures and possible improvements.
Keywords: sustainability, disclosures, forest-based sector, accounting

1. INTRODUCTION

The forest-based sector plays a central role in a bioeconomy – it provides materials, bioenergy, and ecosystem services. Its sustainable development is a necessary precondition for a successful forest-based bioeconomy. Therefore, disclosures of information for sustainability from companies in this sector is essential.

The regulations of sustainability disclosures are effective in European Union as of January 1, 2017, with Directive 2014/95/EU. They are transposed in Bulgarian law with Accounting Act, which requires preparation of non-financial statements. These statements should contain financial and non-financial information on environmental, social, and other significant issues (Zakon za schetovodstvoto, 2015, DV. No. 95, last modified: 2023). The provisions are obligatory for large enterprises, which are enterprises of public interest and which, at December 31 of the reporting period, exceed the criterion for the average headcount of 500 during the financial year.

Large enterprises are enterprises, which at December 31 of the current reporting period exceed at least two of the following criteria:
1. carrying amount of the assets – BGN 38 000 000 (EUR 19 429 091)
2. net sales revenue – BGN 76 000 000 (EUR 38 858 183)
3. average number of employees for the reporting period: 250.

The enterprises of public interest are listed companies, credit institutions, insurers and reinsurers, pension insurance companies, investment firms, and others.

According to the Bulgarian Public Enterprises Act (Zakon za publichnite predpriyatia, 2019, DV. No. 79, last modified: 2023), state enterprises that manage state-owned forest territories are also required to disclose non-financial sustainability information.

The main purpose of the research is to analyze the disclosure of sustainability information regarding the forestry sector in Bulgaria. To achieve this, statements and reports from state enterprises are examined. Problems and potential improvements are analyzed.

2. LEGAL REQUIREMENTS FOR SUSTAINABILITY DISCLOSURES IN BULGARIA

In modern conditions, financial indicators are not sufficient to analyze the overall condition of the enterprise. Non-financial disclosures are increasingly considered the most critical reporting tool for presenting a company's dynamics. Many internal and external stakeholders are showing increasing interest in the environmental and social performance of organizations. Pressure from local communities, environmental activist groups and business partners leads to the emergence of new reporting systems for non-financial disclosures – environmental accounting, social accounting, corporate social reporting, sustainability reporting, non-financial information, integrated reporting, etc. In the European Union, the term "non-financial statement" has been in use for a long time, but in the last two years, there has been an emphasis on "sustainability reporting".

In compliance with Accounting Act non-financial statements should contain information on:

1. a brief description of the business model of the enterprise – goal, strategy, organizational structure, infrastructure, products, and policies
2. a description of the policies adopted and followed by the enterprise in respect of environmental and social issues, including the activities performed during the reporting period and the results
3. the objectives, risks and tasks that lie ahead in terms of environmental and social policies, including a description of activities that would have an adverse impact on ecology, employees, or other social issues
4. a description of the key indicators of the results of the activities related to environmental and social issues.

Based on law, non-financial statements can be presented in two ways:

- in a report on operations (annual management report), which contains non-financial information.
- as a separate report, which is published together with the report on operations or is publicly available on the website of the enterprise, which fact shall be disclosed in the report on operations.

There are no additional requirements for the publication of non-financial information in the legislation. Guidance can be found in Directive 2014/95/EU. It sets the frameworks that can be used – undertakings may rely on national frameworks, Union-based frameworks such as the Eco-Management and Audit Scheme, or international frameworks such as the United Nations (UN) Global Compact, the Guiding Principles on Business and Human Rights implementing the UN 'Protect, Respect and Remedy' Framework, the Organization for Economic Co-operation and Development Guidelines for Multinational Enterprises, the International Organization for Standardization's ISO 26000, the International Labor Organization's Tripartite Declaration of principles concerning multinational enterprises and social policy, the Global Reporting Initiative, or other recognized international frameworks (Directive 2014/95 / EU, par. 9). Other documents also include *the International Framework for Integrated Reporting* (Communication from the Commission, 2017).

According to the European Guidelines the elements of the non-financial statement are Business model, Policies and due diligence, Outcome, Principal risks and their management, Key performance indicators, and Thematic aspects (Communication from the Commission, 2017). They are similar those specified in the Accounting Act.

The European regulations do not require explicit compliance with one of these frameworks. This approach is not appropriate and cannot lead to the compilation of high-quality disclosures. There are many empirical studies into the omissions in the preparation of non-financial statements based on European regulations (Pelikanova, 2019; Borodin, 2019; Muserra, 2020; Krasodomska, 2020; Veysel, 2022). The European Commission has published a study as well (Study on the Non-Financial Reporting Directive, 2020). It proves that more freedom in the reporting limits comparability across companies. The study also identifies that the lack of precision in the requirements and the large number of standards and frameworks make it difficult for companies to know exactly what information they should report. In this regard a new directive was adopted in December 2022 (Directive 2022/2464). On 31 July 2023, the European Sustainability Reporting Standards (ESRS) have been published. The standards aim more comparability and increased disclosures (Veysel, A., 2023). They cover the full range of environmental, social, and governance issues, including climate change, biodiversity, and human rights. However, their efficacy in addressing certain issues will be limited. The findings of empirical research strongly indicate that.

3. AN EMPIRICAL RESEARCH INTO THE SUSTAINABILITY DISCLOSURES IN FOREST-BASED SECTOR IN BULGARIA

The population of the empirical research includes all state enterprises that manage state-owned forest territories in Bulgaria. They are registered in accordance with the Bulgarian Forests Act (Zakon za gorite, 2011, DV. No. 19, last modified: 2023) and include:

- Northwest State Enterprise (Severozapadno darzhavno predpriyatie), Identification number: 201617476
- North Central State Enterprise (Severnotsentralno darzhavno predpriyatie), Identification number: 201616805
- Northeast State Enterprise (Severoiztochno darzhavno predpriyatie), Identification number: 201617412
- Southwest State Enterprise (Yugozapadno darzhavno predpriyatie), Identification number: 201627506
- South Central State Enterprise (Yuzhnotsentralno darzhavno predpriyatie), Identification number: 201619580
- Southeast State Enterprise (Yugoiztochno darzhavno predpriyatie), Identification number: 201617654

These state enterprises manage 3 million hectares of forest territories, or 73% of all forests in Bulgaria (Cholakova, 2023). Of these, 57% are designated as areas of the ecological network.

Enterprises have the obligation to publish their financial statements, annual management reports, non-financial statements, and auditor`s reports by September 30 of the following year

– until 30 September 2023 for 2022.[3] The following table includes main indicators from the financial statements and the annual management reports about them:

Table 1. Main indicators for Bulgarian state enterprises in forest-based sector for 2022

Enterprise	Carrying amount of assets (in thousands of EUR)	Net sales revenue (in thousands of EUR)	Average number of employees
Northwest State Enterprise	20 727	19 467	649
North Central State Enterprise	46 757	23 703	820
Northeast State Enterprise	36 619	29 406	961
Southwest State Enterprise	155 282	39 424	1 559
South Central State Enterprise	110 744	59 770	1 921
Southeast State Enterprise	37 745	39 290	1 464
Total	407 874	211 060	7 374

Source: Author`s research

Published documents in the Commercial Register were carefully checked for non-financial information. The classification of the companies according to the approach to disclosure of non-financial information is given in the following table:

Table 2. Disclosure of non-financial information from Bulgarian state enterprises in forest-based sector for 2022

Enterprises	Number of enterprises
Enterprises that publish non-financial statement	1
Enterprises that disclose non-financial information in the annual management report	0
Enterprises that do not disclose systematic non-financial information	5
Total	6

Source: Author`s research

The table shows that only one of the six Bulgarian state enterprises in the forest-based sector disclosures non-financial information. A review of the documents also shows that only two of the six enterprises are published the independent auditor's report. Therefore, possible misstatements in the information are not clear. Previous studies have demonstrated comparable results, and our findings further support this consistent trend (Ventsislavova Georgieva, D., Bankova, D., 2020).

The published non-financial statement includes only some requirements of Accounting Act – a brief description of the business model and a description of the policies in respect of environmental and social issues. However, they are limited and not sufficient for high-quality

[3] The website of the Commercial Register, https://portal.registryagency.bg/ [Accessed January 3, 2024].

non-financial statements. It doesn't even emphasize the objectives, risks, tasks, and a description of the key indicators of the results.

The annual management reports contain some analysis of financial and non-financial information on issues related to environment and employees, but it is not adequate for the purposes of sustainability. It is interesting that there is no enterprise using a framework for sustainability disclosure.

The obligation to disclose information about the sustainability of enterprises in the forest-based sector is not based on the Accounting Act, but under the Public Enterprises Act. Therefore, it could be argued that the rules are not clear enough. Other research also shows that the Bulgarian companies disclose non-financial information, which are limited and incomplete, only in case of legal obligation (Veysel, A., 2022). This demonstrates a failure to conform to existing regulations.

4. CONCLUSIONS

The results of the study indicate that Bulgarian enterprises in the forest-based sector do not adhere to the requirements for disclosing information on sustainability. They do not even publish all the information required by law. This issue can be addressed by emphasizing legal provisions, improving the state control, and highlighting best practices in this area. However, the European Union's policy involves adopting additional standards. Companies that do not meet the minimum requirements cannot be expected to comply to detailed standards. The current provisions are sufficient, when applied in conjunction with the best practices embedded within international frameworks. Their neglecting cannot be compensated by adopting additional complex rules.

REFERENCES

1. Borodin, A. et al. (2019). The impact of the publication of non-financial statements on the financial performance of companies with the identification of intersectoral features. Entrepreneurship and Sustainability Issues, 7(2), pp. 1666-1685.
2. Cholakova, A. (2023). Ima reshenie shestte gorski predpriyatia veche da ne sa firmi, no dobro li e to?, https://www.actualno.com/society/ima-reshenie-shestte-gorski-predprijatija-veche-da-ne-sa-firmi-no-dobro-li-e-to-news_2112048.html [Accessed January 3, 2024].
3. Communication from the Commission – Guidelines on non-financial reporting (methodology for reporting non-financial information), 2017. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017XC0705(01) [Accessed January 3, 2024].
4. Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0095 [Accessed January 3, 2024].
5. Directive 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32022L2464 [Accessed January 3, 2024].

6. Krasodomska, J., Zarzycka, E. (2020). Key performance indicators disclosure in the context of the EU Directive: when does stakeholder pressure matter? Meditari Accountancy Research, 29(7).
7. Muserra, A.L. et al. (2020). Sustainable Development and the European Union Policy on Non-Financial Information: An Italian Empirical Analysis. Corporate Social Responsibility and Environmental Management, 27(1), pp. 22-31.
8. Pelikanova, R. M. (2019). Corporate social responsibility information in annual reports in the EU-A Czech case study. Sustainability (Switzerland), 11(1), 237.
9. Published financial statements, annual management reports, non-financial statements, and auditor`s reports on the website of the Commercial Register, https://portal.registryagency.bg/ [Accessed January 3, 2024].
10. Study on the Non-Financial Reporting Directive. Final report, 2020. Available at: https://op.europa.eu/en/publication-detail/-/publication/1ef8fe0e-98e1-11eb-b85c-01aa75ed71a1/language-en [Accessed January 3, 2024].
11. Ventsislavova Georgieva, D., Bankova, D. (2020): Problems in Audit and Reporting in Bulgaria's Forestry. 13th International Scientific Conference WoodEMA 2020 – Sustainability of forest-based industries in the global economy – Vinkovci, Croatia. WoodEMA, i.a. – International Association for Economics and Management in Wood Processingand Furniture Manufacturing University of Zagreb, pp. 31-36, ISBN: 978-953-57822-8-5.
12. Veysel, A. (2022). Non-Financial Information Disclosures by Bulgarian Listed Companies. – Economic Studies (Ikonomicheski Izsledvania), 31(3), pp. 17-33. ISSN 0205-3292.
13. Veysel, A. (2023) Aktualni aspekti na otchitaneto i uverenostta vav vrazka s ustoychivostta, statia, spisanie IDES, br. 2, Sofia, ISSN: 1314-8990.
14. Zakon za gorite, 2011, DV. No. 19, last modified: 2023, DV. br. 106.
15. Zakon za publichnite predpriyatia, 2019, DV. No. 79, last modified: 2023, DV. br. 84.
16. Zakon za schetovodstvoto, 2015, DV. br. 95, last modified: 2023, DV. br. 105.

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PERCEPTION OF THE TERM AUDIT IN THE FOREST SECTOR

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Abstract: This paper unveils the term audit applied to the forest industry based on scientific literature in Science Direct from 2005 to December 2023. The research toolkit covers methods of analysis, synthesis, and a structured approach to searching the scientific literature. The sample of the study consistence 9 literature sources. Three sections are included in the structure of this paper. The research toolkit is clarified in the first section. The results are shown in the second section. The discussion is presented in the third section.
Keywords: audit, forest sector, control

1. INTRODUCTION

There are many uses for forests and a variety of interests related to them. Aside from protecting the ecosystem and the social values of forests, corporations, local communities, and non-governmental organizations all have their own objectives that include making money from commercial uses of forests and saving the environment (Sayer et al., 2015).

The beginning of the audit idea can be traced back to the financial sector, where it achieved significance throughout the 1970s and 1980s (Power, 1997). Subsequently, it was adopted by some industries, including forestry and other environmental domains. Performance evaluation is the systematic examination of an organization's performance, often in comparison to a predetermined benchmark. Effectiveness and efficiency are usually determined by certain criteria.

Auditing in the forest sector is necessary to maintain the balance between different stakeholders. From the point of view of management, auditing is a tool for measuring the effectiveness of controlling functions and internal control of organizations (Lambovska and Yordanov, 2020). Current uncertainty and rapidly developing technologies call for a variety of management control mechanisms (Dombashov, 2023).

This paper aims to unveil the views of the term audit applied to the forest industry based on the scientific literature in Science Direct from 2005 to December 2023.

The research toolkit covers methods of analysis, synthesis, and the RETREAT framework (Booth et al., 2018) for structured searching of the literature.

Three sections are included in the structure of this paper. The research toolkit is clarified in the first section. The results are shown in the second section. The discussion is presented in the third section.

2. RESEARCH TOOLKIT

This research is based on a structured review of the literature available in the Science Direct database.

The search algorithm is based on the RETREAT framework (Booth et al., 2018) and includes its main phases (Figure 1): determining the main research elements, conducting the search, and synthesizing the obtained results.

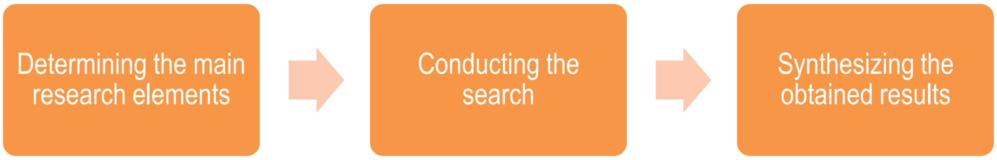

Figure 1. Adapted RETREAT framework for this research (Booth et al., 2018)

The main components of phase 1 are:

- Research question: What is the perception of the term audit in the forest sector?
- Searching source: Science Direct database;
- Search phrase: "audit in the forest sector";
- Period: from 2005 to 2023;
- Search strategy: the search phrase should appear in the document's title, abstract, or keywords;
- Records to be open-access;

At this phase, the author of the paper uses a structured search approach.

During the second phase, 9 results were found within the specified period and limitation. They constitute the research sample.

At phase 3, the sample is analysed, the results are summaries, and conclusions were drawn. Analysis and synthesis methods were here applied.

3. RESULTS

Sari and colleagues' (2019) research suggest using forest landscape *audits to assess the consistency of multi-sector landscape governance*. They specify that *evaluating the efficacy of governance structures over specific systems, operations, programs, activities, and organizations is the aim of the audit*. Sari et al. (2019) focus on alternative conflict resolution processes among multi-sector governance stakeholders. They provide a way to assess how effectively governance frameworks manage complexity in forest environments. Using standard performance, audit procedures:

(1) describe the interactions between various sectoral stakeholders;

(2) evaluate how well governance arrangements handle complexity in a forest landscape;

(3) provide recommendations for more effective multi-sectoral governance of forest landscapes using a landscape approach and standard performance audit procedures.

According to Halalisan et al. (2023), *performance may be verified via two separate third-party mechanisms: auditing and accreditation*. The authors emphasize that auditing is an effective tool that is relatively more expensive and time-consuming than accreditation.

The results of this research cover 9 papers (Table 1).

Table 1. Essence of perceptions for audits in the forest sector

N	Authors	Year of publication	Essence of perception
1	Chan, D. Y. L., Yang, K. H., Hsu, C. H., Chien, M. H., & Hong, G. B.	2007	*focuses on energy audits*
2	Giesecke, A. G.	2005	the efficacy of audited financial statements lies in their ability to faithfully depict the various aspects of a company's operations and provide comprehensive information on environmental reporting of sustainability
3	Halalisan, F., Romero, C., Popa, B., Landin, G. A., Talpa, N., Abrudan, I. V.	2023	*performance may be verified via two separate third-party mechanisms: auditing and accreditation*
4	Maletz, O., & Tysiachniouk, M.	2009	*the auditors are at the heart of opportunities for further investigation and research into the nature of certification in the forest sector*
5	Sari, D. A., Margules, C., Lim, H. S., Widyatmaka, F., Sayer, J., Dale, A., Macgregor, C.	2021	*the process of verifying circumstances in accordance with relevant criteria*
6	Sari, D. A., Sayer, J., Margules, C., Boedhihartono, A. K.	2019	*evaluating the efficacy of governance structures over specific systems, operations, programs, activities, and organizations is the aim of the audit*
7	Su, T. L., Chan, D. Y. L., Hung, C. Y., & Hong, G. B.	2013	*the main focus should be the energy audit*
8	Susilawati, D., & Kanowski, P.	2020	*observed that the PHPL evaluation mostly functions as a document-based audit, with a strong emphasis on attaining a passing mark rather than emphasizing the enhancement of sustainable forest management*
9	Susilawati, D., Kanowski, P. J.	2022	*place constraints at the center of implementing auditing and monitoring protocols*

In their research, Sari et al. (2021) defines *an audit as the process of verifying circumstances in accordance with relevant criteria*. They collect four forms of evidence to achieve this objective: corroborative documentary, testimonial, analytical, and physical. Their findings on auditing the success of government programs at a national level may be simplified by adopting a new technique of auditing at landscape scales.

According to Giesecke (2005), *the efficacy of audited financial statements lies in their ability to faithfully depict the various aspects of a company's operations and provide comprehensive information on environmental reporting of sustainability*. This, in turn, furnishes financial markets and stockholders with valuable insights into the robust policies of reputable companies.

Susilawati et al. (2022) *place constraints at the center of implementing auditing and monitoring protocols*.

According to Maletz et al. (2009), based on the existing body of literature pertaining to financial auditing, it is posited that the crux of this enigma lies in the inherent vagueness of standards and certification procedures, necessitating implementing entities to interpret and navigate their implications within distinct local contexts. They point out that *the auditors are at the heart of opportunities for further investigation and research into the nature of certification in the forest sector*.

A study by Su et al. (2013) states that *the main focus should be the energy audit*. Based on Avami and Sattari (2007), energy audits provide a *very thorough method for enhancing the energy efficiency of an established system*. According to these authors, the process of conducting an energy audit encompasses the following stages:

(1) Facilitating the establishment of energy audit systems for energy users;

(2) Aiding energy users in the implementation of energy management strategies and the establishment of energy conservation objectives;

(3) Offering on-site energy audits and offering assistance, technology, and information services pertaining to energy conservation.

Another group of authors (Chan et al., 2007) focuses again *on energy audits and the methodology indicated by Avami and Sattari* (2007).

Some authors (Susilawati and Kanowski, 2020) observed that the *PHPL* (Pengelolaan Hutan Produksi Lestari - certification for plantations) *evaluation mostly functions as a document-based audit*, with a strong emphasis on attaining a passing mark rather than emphasizing the enhancement of sustainable forest management. Similarly, auditors are only needed to check compliance with formal paperwork for SVLK (Indonesian Timber Legality Verification System) verification, except for the execution of the environmental management criteria.

4. DISCUSION

The current research on the perception of the term audit in the forest sector in the scientific indexed literature gives reason to draw the following conclusions:

- The results of the research show that there is an insufficient number of publications on the researched topic (Table 1).
- Auditing in the forest sector is applicable and necessary, as discussed by all authors in the sample.
- Three of the sources under consideration clearly outline the methodology for applying audits in the forest sector.

- Most of the authors perceive the application of the audit as part of the certification process.
- All papers focus on characteristics, mechanisms, and manifestations of the audit likewise in a financial audit.

In conclusion, the author of the paper can generalize that the audit in the forest sector is an essential modern control concept that aims to protect and use the environment responsibly. The author of this paper supports the notion that the mechanisms for conducting the audit in the forestry sector should be based on the concepts of the financial audit.

The author suggests two main directions for future research on this topic:

- Implementation of the concept of "audit in the forest sector".
- Expanding research on the specified topic through new databases and more literature.

5. CONCLUSION

This paper unveil the perception of the term audit applied to the forest industry based on the scientific literature in Science Direct.

The toolkit of the paper includes the methods of analysis, synthesis, and the RETREAT framework for structured searching of the literature.

The sample of the research covers 9 papers. It was formed on the basis of the following limitations: the research period 2005 - 2023; the sources that contain the term "audit in the forest sector" in the title, abstract, or keywords.

The main recommendation of the author of the paper is the audit to be implemented of the concept of "audit in the forest sector" is a modern control concept aimed at the protection and prudent use of the environment.

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REFERENCES

1. Avami, A., & Sattari, S. (2007). Energy conservation opportunities: cement industry in Iran.
2. Booth, A., Noyes, J., Flemming, K., Gerhardus, A., Wahlster, P., van der Wilt, G. J., ... & Rehfuess, E. (2018). Structured methodology review identified seven (RETREAT) criteria for selecting qualitative evidence synthesis approaches. *Journal of clinical epidemiology*, 99, 41-52.
3. Chan, D. Y. L., Yang, K. H., Hsu, C. H., Chien, M. H., & Hong, G. B. (2007). Current situation of energy conservation in high energy-consuming industries in Taiwan. *Energy policy*, 35(1), 202-209.
4. Dombashov, R. (2023). CONCEPTS AND TOOLS FOR BUDGETARY CONTROL OF THE COMPANY IN THE BULGARIAN SCIENTIFIC LITERATURE: A REVIEW. Proceedings of XXVI International Scientific Conference "TRANSPORT 2023" (pp. 110-115), Sofia, Bulgaria.
5. Giesecke, A. G. (2005). Sustainability with Sanity. In Using Cereal Science and Technology for the Benefit of Consumers (pp. 365-369). Woodhead Publishing.
6. Halalisan, F., Romero, C., Popa, B., Landin, G. A., Talpa, N., Abrudan, I. V. (2023). Global assessment of FSC forest management certification auditing through analysis of accreditation reports. *Land Use Policy*, 131, 106724.

7. Lambovska, M., & Yordanov, K. (2020). Understanding 'Motivation - Internal Control' Relations in Municipalities. TEM Journal, 9(2), 662-671. DOI: 10.18421/TEM92-32
8. Maletz, O., & Tysiachniouk, M. (2009). The effect of expertise on the quality of forest standards implementation: The case of FSC forest certification in Russia. *Forest Policy and Economics*, 11(5-6), 422-428.
9. Power, M. (1997). The audit society: Rituals of verification. OUP Oxford.
10. Sari, D. A., Margules, C., Lim, H. S., Widyatmaka, F., Sayer, J., Dale, A., Macgregor, C. (2021). Evaluating policy coherence: A case study of peatland forests on the Kampar Peninsula landscape, Indonesia. *Land Use Policy*, 105, 105396.
11. Sari, D. A., Sayer, J., Margules, C., Klintuni Boedhihartono, A. (2019). Determining the effectiveness of forest landscape governance: A case study from the Sendang landscape. South Sumatra. *Forest Policy and Economics*. Volume 102. pp. 17-28. ISSN 1389-9341. https://doi.org/10.1016/j.forpol.2019.01.014.
12. Sayer, J., Margules, C., Boedhihartono, A. K., Dale, A., Sunderland, T., Supriatna, J., & Saryanthi, R. (2015). Landscape approaches; what are the pre-conditions for success?. *Sustainability Science*, 10, 345-355.
13. Su, T. L., Chan, D. Y. L., Hung, C. Y., & Hong, G. B. (2013). The status of energy conservation in Taiwan's cement industry. *Energy Policy*, 60, 481-486.
14. Susilawati, D., & Kanowski, P. (2020). Cleaner production in the Indonesian pulp and paper sector: Improving sustainability and legality compliance in the value chain. *Journal of Cleaner Production*, 248, 119259.
15. Susilawati, D., Kanowski, P. J. (2022). Improving Indonesia's timber legality and sustainability verification system: Proposals based on case studies of natural forest-, corporate tree plantation- and smallholder-based value chains. *Environmental Science & Policy*, 137, 384-395.

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FOSTERING HUMAN CAPITAL DEVELOPMENT IN THE WOOD SECTOR THROUGH FDI FOR SMALL OPEN ECONOMIES (THE CASE OF BULGARIA)

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Abstract: The main goal of this paper is to study the role of multinational enterprises for human capital development in the wood sector in Bulgaria. It employs a unique set of firm level data to conduct a comparative analysis of practices of domestic firms and foreign subsidiaries. The study finds evidences that MNEs significantly affect the enhancement of human capital. The inquiry reviles that foreign affiliates exhibit a higher level of commitment to training when compared to domestic firms, impart more advanced knowledge, emphasize CVT over OJT, engage in partnerships with subcontractors, and collaborate with local research institutions. There are also suggestions about the presence of positive spillover effects and a gradual reduction of differences between local and foreign firms.
Keywords: foreign direct investment, multinational enterprise, human capital, wood sector

1. INTRODUCTION

In the present era of knowledge-based economies, human capital plays a pivotal role in driving growth, and enhancing competitiveness. For small emerging markets, fostering the development of human capital is an impossible challenge due to limited internal resources and relatively lower level of technological advancement. Such countries heavily depend on import of FDI. This is even more valid for forestry and wood processing, which are traditionally underestimated and suffer from a lack of skilled workers.

The main aim of this research paper is to assess the impact of FDI on the development of human capital within Bulgaria's wood sector. To achieve this objective, the study employs unique data at the firm level. The paper conducts a comprehensive analysis of the diverse forms of knowledge transfer, intensity, the modes of educational practices, and the resulting influence on local human capital. Moreover, the significance of MNE is highlighted through a comparison with the practices of domestic firms.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW.

All MNEs share a common characteristic that sets them apart from purely national firms. They possess a firm specific asset (Grant, 1996), often referred to as "knowledge-capital” (Markusen&Venables, 1998). This knowldge can be considered as a “public good” within the company and all MNE’s subsidiaries can employ it simultaneously without any loss in value. The "knowledge-capital” motivates MNCs to expand their production internationally by allowing them to achieve substantial economies of scale at the firm level, far exceeding the plant level losses incurred by smaller-scale of overseas production (Navaretti, G. & Venables, 2004). The strategic significance of human capital as a part of "knowledge-capital” and its role within corporations is a crucial aspect in the conditions of a knowledge-based economy (Kanter, 1997). The competitive environment in contemporary times is characterized by swift technological advancements, which leads to an increased demand for specialized knowledge. MNE are facing heightened pressure to foster knowledge sharing and generate new insights between the parent company and its transnational subsidiaries (Michailova& Mustaffa, 2012).

The effect of FDI on human capital is not straightforward (Kolev, 2012). In its dedicated report, UNCTAD (2000) suggests that MNEs are more likely to invest in human capital upgrading compared to local companies. They demonstrate a greater awareness of emerging trends, necessity for innovative skill development and are more willing to align their training programs with global markets. This viewpoint is widely supported by various studies carried out in EEC (Inzelt, 2008), Africa (Agbola, 2013), Asia (Mody et al., 1999), and China (Liu et al.,2001). Another group of studies fails to discover evidence supporting the development of local human capital (Lukas, 1990; Chidlow et al., 2009). This suggests that in other scenarios, MNE take advantage of the skilled labor force available in the host economy without making additional investments in its education. There is very little previous research on this matter concerning the wood industry. Studies of FDI in forestry and wood processing supports positive effects on human capital in Slovakia (Merková et al., 2012) and Latin America (Pereyra & Alonso, 2024). In contrast, Laaksonen-Craig (2008) argues that the long-term effect cannot be guaranteed as it is strongly dependent on various local or political factors, including the motives driving the expansion of MNE.

3. FDI AND MNES ACTIVITIES IN BULGARIAN WOOD SECTOR.

After the liberalization in the middle of 1990s until first decade of XXI century, Bulgaria managed to accumulate FDI amounting 60% of its GDP. The wood industry in Bulgaria is considered to be one of the less attractive sectors for foreign investors. As of 2020, it accounts for a mere 1,8% of the total FDI stock and 1,1% of all foreign affiliates that are actively opperating within the country. As of 2010, the foreign affiliates comprised 4% of all firms, experiencing consistently declining and by 2020, their representation had halved, accounting for only 2%. Despite their diminishing presence, foreign companies contribute a significantly higher share of added value compared to the national average (between 26% and 29% over the past decade). This achievement can be attributed to their exceptional productivity, superior organizational practices, and the distinctive characteristics of the final product. The percentage of employees in foreign companies has remained steady at approximately 13%, indicating a trend towards consolidation and expansion among the remaining MNE's affiliates in the sector. The labor productivity data reveals a significant performance gap between foreign and domestic firms, with foreign entities outperforming their Bulgarian counterparts. MNE's affiliates achieved three times higher efficiency per employee in 2010 compared to local companies. By 2020, the discrepancy had decreased by around 30%, possibly due to the positive spillover effects and heightened investment activities of domestic firms.

The wage is one of the most commonly used indirect measures of human capital (Mincer, 1958; C.B. Mulligan, X. Sala-i-Martin, 1997), since it usually correlates with the level of skill and education possessed by an individual. Higher-skilled workers tend to be more productive, and employers are willing to pay them higher wages to reflect their greater contributions to output. Therefore, the growth in real wages can be attributed (at least partially) to the accumulation of human capital. It comes as no surprise that the data on personnel costs per a person employed demonstrate a significant similarity to those of labor productivity. In foreign subsidiaries, they are 2-2,5 times higher than those in local firms, with 81% increase in real terms till 2020.

Based on the short discriptive analysis, it is evident that MNE's affiliates operating in the wood sector in Bulgaria utilize labor resources with notably advanced skills and qualifications. Moreover, these companies are dedicated to the ongoing development and enhancement of human capital. This leads to the fundamental question of how foreign affiliates manage to achieve this, and what sets their practices apart from those of local firms.

4. MNE AND HUMAN CAPITAL DEVELOPMENT IN BULGARIAN WOOD SECTOR

In order to address the posed question, we utilize a unique set of firm level data obtained from EUROSTAT study on continuing education in EU member states, conducted periodically on every five years. The data used in the analysis was collected in 2015 and released in 2017. The most recent survey dated from 2020 and released in 2023. The rationale for utilizing older data is the significant bias caused by COVID-19 pandemic on the latest one, which does not accurately reflect the companies' sustainable practices.

In general, companies provide two types of training to employees. "On-the-job" (OJT) training occurs directly within the context of the job itself. It is a method of an acquisition of narrow skills and experience while actively engaged in work tasks within a specific job or workplace environment. Continuing vocational training (CVT) is a process of acquisition of much broader new knowledge, to enhance one's career prospects and performance after taking the job. CVT takes place throughout a person's career to keep their skills up-to-date.

The EUROSTAT survey data reveals that both domestic and foreign enterprises provide their employees with initial OJT (Table 1). The degree of intensity in these trainings is markedly greater in foreign subsidiaries (46,9%) compared to local competitors (37,3%). Domestic firms mainly rely on traditional "on-the-job" training, where new employees are trained by more experienced or older workers (32.2% of cases) (Table 1). Conversely, foreign subsidiaries involve their employees in conferences, workshops, trade fairs, lectures, or organize periodical learning or quality circles (42.8% of cases in total). A significant number of employees undergo job rotation, exchanges, and study visits (14.3% for multinational corporations versus 11.9% for local firms). Therefore, while both local and foreign companies show a similar preference towards on-the-job training, foreign subsidiaries offer a much broader, diverse, and advanced level of knowledge transfer practices.

Table 1. "On-the-job" training by foreign and local firms

	Foreign affiliates	Local firms
Share of the firms, organizing OJT	46,9%	37,3%
Types of OJT:		
Coaching (classical OJT)	14,3%	32,2%
Job rotation, exchanges, study visits	14,3%	11,9%
Conferences, workshops, trade fairs or lectures	26,5%	16,4%
Learning or quality circles	16,3%	8,8%
Planned training by self-directed learning/e-learning	8,2%	7,1%

Compared to OJT, the differences in CVT between companies are less distinct. Nevertheless, the magnitude of these CVT is significantly greater among foreign affiliates, with an average of 17 hours per participant, which is three times higher than that of local counterparts (Table 2). Even more striking is the contrast in hours per firm, which is 6.5 times higher in favor of MNEs.

Table 2. Average paid working time spent on continuing vocational training

	From all firms	Average hours CVT		Per participant, by type of the firm		
		Per participant	Per firm	Small firms	Medium sized firms	Large firms
Foreign affiliates	34,7%	17,0	4179	25	55	31
Local firms	28,2%	6,1	644	34	16	9

The data reveals that both national and foreign companies prioritize CVT to enhance the technical and practical abilities of workers directly involved in production (Table 3). However, there are notable distinctions between the two in terms of the technologies they employ.

Table 3. Acquired skills through continuing vocational training in foreign and local firms

Type of the skill	Foreign affiliates	Local firms
IT professional skills	30,9%	9,2%
Technical, practical or job-specific skills	29,1%	37,2%
Team working skills	10,9%	15,9%
Management skills	9,1%	5,8%
Problem solving skills	5,5%	7,2%
Foreign language skills	5,5%	1,4%
General IT skills	3,6%	6,8%
Customer handling skills	3,6%	12,6%
Other skills not listed above	1,8%	1,9%
Office administration skills	0,0%	1,0%
Oral or written communication skills	0,0%	0,5%
Numeracy and/or literacy skills	0,0%	0,5%

Foreign companies heavily rely on the utilization of IT technologies while local manufacturers, constrained by limited capital resources, place IT professional skills as a lower priority in their training programs. The foreign affiliates upgrade the local human capital with much higher technological knowledge and skills (IT professional, technical job-specific skills - 60%). Conversely, local companies place greater emphasis on developing soft skills such as teamwork, problem-solving, and effective communication, accounting for 54% of their training focus. This discrepancy arises from the MNE ability to attract highly qualified workers with higher wages, who also receive additional training to enhance their professional qualifications.

In contrast, local companies adopt a cost-minimizing strategy by hiring unskilled workers from underdeveloped regions, abundant with natural inputs.

Table 4. Providers of continuing vocational training for foreign and local firms

Type of the provider	Foreign affiliates	Local firms
Private training companies	43,8%	45,8%
Schools, colleges, universities	18,8%	2,4%
Equipment suppliers, parent/associate companies	18,8%	7,2%
Public training institutions (financed or guided by the government)	12,5%	12,0%
Other training providers	6,3%	21,7%
Employer's associations, chambers of commerce, sector bodies	0,0%	10,8%

Foreign subsidiaries exhibit similar preferences as their domestic rivals to rely on external training organizations instead of internal knowledge transfer within the multinational organization (Table 4). However, there are several significant differences. MNEs display a significantly greater propensity to establish partnerships with local universities and research institutions, thereby acquiring additional novel technological knowledge that is specific to the local economy. This knowledge is then assimilated into the firm's internal „knowledge-capital", leading to adaptations in production processes. Unlike domestic firms, foreign subsidiaries engage in more extensive interactions with their suppliers and customers, actively encouraging partners' specialists to conduct trainings in order to enhance production quality and ensure long-term contractual relationships. However, the fact that MNEs tend to remain relatively detached from local sectoral networks and players can be regarded as a drawback, demonstrating "enclave development" model of natural resource-seeking FDI.

5. CONCLUSION

The study conludes that MNEs, despite being few in number, possess the capacity to significantly impact the enhancement of human capital within the wood sector in Bulgaria. Evidence suggests that foreign affiliates exhibit a higher level of commitment to training when compared to domestic firms, impart more advanced knowledge, emphasize CVT over OJT, engage in partnerships with subcontractors, and collaborate with local research institutions. There are also assumptions about the presence of positive spillover effects that accelerate the development of local firms and gradually reduce their differences with MNCs.

REFERENCES

1. Agbola, F. W.(2013)*: Does human capital constrain the impact of foreign direct investment and remittances on economic growth in Ghana?*. Applied Economics, 45(19), pp. 2853-2862
2. Mulligan, X., Sala-i-Martin, A. (1997) *Labor income-based measure of the value of human capital: An application to the states of the United States*. Japan and the World Economy, 9 (2), pp. 159-191.

3. Chidlow, A; Salciuviene, L., Young, S.(2009): *Regional determinants of inward FDI distribution in Poland*. International Business Review, 18(2), pp. 119-133.
4. Grant, R. (1996): *Toward a knowledge-based theory of the firm*. Strategic Management Journal, 17, pp.109-122.
5. Inzelt, A. (2008): *The inflow of highly skilled workers into Hungary: a by-product of FDI*. The Journal of Technology Transfer, 33(4), pp. 422-438.
6. Kanter, R. (1997): *Restoring people to the heart of the organization of the future*. From: The organization of the future. San Francisco: Jossey-Bass, pp. 139-150.
7. Kolev, K. (2012): Globalization, Transnational Corporations and Regional Development. STENO Publishing House.
8. Laaksonen-Craig, S. (2008): *The Determinants of Foreign Direct Investments in Latin American Forestry and Forest Industry*. Journal of Sustainable Forestry, 27:1-2, pp.172-188
9. Liu, X., Parker, D., Vaidya, K., Wei, Y. (2001): *The impact of foreign direct investment on labour productivity in the Chinese electronics industry*. International Business Review , 10, pp. 421-439.
10. Lucas, R. (1990): *Why capital doesn't flow from rich to poor countries?*. American Economic Review, 80, pp. 92-96.
11. Markusen, J., Venables, A. (1998): *Multinational firms and the new trade theory*. Journal of International Economics, 46(2), pp. 183-203.
12. Merková, M., Drábek, J., Jelačić, D. (2012): *Determinants of Effects of Foreign Direct Investment in Terms of Slovak Republic and Wood-Processing Industry of Slovakia*. Drvna Industrija, 63(2), pp. 129-142.
13. Michailova, S., Mustaffa, Z. (2012): *Subsidiary knowledge flows in multinational corporations: research accomplishments, gaps, and opportunities.* Journal of World Business, 47(3), pp. 383-396.
14. Mincer, J. (1958): *Investment in Human Capital and Personal Income Distribution*. Journal of Political Economy, 66, pp. 281-302.
15. Mody A, Dasgupta S., Sinha S. (1999): *Japanese multinationals in Asia: drivers and attractors*. Oxford Development Studies , 27(2), pp. 149-164.
16. Navaretti, G., Venables, A. (2004): Multinational Firms in the World Economy. Princeton University Press
17. Pereyra, M., Alonso, C. (2024): *FDI for forestry: an impact evaluation of regional development*. Review of Regional Research, 44, pp. 1–20

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CRITERIA FOR MANAGEMENT CONTROL OF FOREST INDUSTRY ENTERPRISES

Rumen Dombashov

Abstract: The management control function is considered important for the management of organizations, including those from the forest industry, and some authors even define it as a management meta-function. The specificity of this function in the forest industry also stems from the need for environmental control in a global aspect. In this regard, setting indicators for management control in these organizations has an important meaning in the context of the sustainable development concept. The purpose of this paper is to derive a system of indicators for forest industry enterprises. The paper is based on a systematic review of publications indexed by Web of Science and Scopus scientometrics databases before 2024. The paper consists of three parts. The first part introduces the research framework of this study. It explains the stages for conducting this systematic review. The second part summarizes the results of the study. The results indicate that the authors apply quantitative and qualitative criteria for management control or a combination of quantitative and qualitative criteria. The third part contains a brief discussion of the research topic.
Keywords: responsibility accounting, management control, criteria, indicators

1. INTRODUCTION

Sustainable forest management yields environmental, social and economic benefits for society. Management of forest industry enterprises is defined as a strategically important process focused on monitoring and measuring results (Martinez et al., 2020). The specificity of the management function “control” in the forest industry also stems from the need for environmental control globally. In this regard, setting criteria (indicators) for management control in forest sector organizations (FSOs) is important in the context of the concept of sustainable development. Criteria for management control are metrics for assessment of management effectiveness. Choosing the appropriate indicators for these enterprises is extremely challenging as part of the management meta-function “controlling” (Angelova, 2023) and given that their dynamics are difficult to measure correctly.

The aim of this report is to devise a system of indicators for management control of forest industry enterprises. The study is based on publications in the Web of Science and Scopus indexed scientific databases for the period until the end of 2023. Methodologically, the review is based on the PRISMA methodology (Moher et al., 2009) using a structured approach.

The report consists of three parts. The first part introduces the research framework of the review. It clarifies the stages of the systematic review of the scientific literature. The second part summarises the results of this study. The third part contains a brief discussion on the topic of the study.

2. METHODOLOGY

This review of the scientific literature is systematic in nature, uses a structured approach and is based on the PRISMA methodology (Moher et al., 2009).

The review was carried out in two stages: development of a search protocol and conducting the search.

2.1. Stage "Development of a search protocol"

The review protocol for the scientific literature conducted in this report covers those elements for a systematic review of the scientific literature recommended by Moher et al. (2009). The search was conducted in the Web of Science and Scopus scientific databases for the period until the end of 2023 with the phrases:

WoS: (management NEAR/0 control) AND (forest* AND (industry OR sector))

Scopus: (management PRE/0 control) AND (forest* AND (industry OR sector))

Sources not related to the topic of this review are beyond its purpose and without open access, are excluded from this study.

1.2. Stage "Conducting the search"

As a result of the "original search" activity, 25 records (scientific publications) have been found. After reviewing them, 21 records were excluded, which are outside the purpose of the study. In the final activity, the range of sources used was reduced to 4 sources.

3. RESULTS

The results of this study are presented in Table 1. The indicators for management control in the forest sector enterprises are grouped by the author of the report into four main groups as follows: for measuring the external environmental risk, measuring the financial and economic status, measuring internal management processes and those related to contribution to the local economy and responsibility to society.

According to Martinez et.al. (2020a), the creation of a set of indicators allows assessment and effective monitoring of the management of Cuban forest sector enterprises according to their potential. These authors outline 30 indicators and analyse the vertical and horizontal relations between them. The set of indicators has been obtained through the direct survey method of specialists working in the country's forest sector, as well as by academics working in the field (Martinez et al., 2020a). To study the correlation between them, the authors grouped them into five main groups: Financial Perspective, Customer Perspective, Environmental Perspective, Internal Process Perspective and Learning and Growth Perspective (Martinez et al., 2020a).

In another article on the topic of the study, the same authors focus on the implementation of a set of indicators for sustainable forest management and assessment of the level of efficiency of the forest industry enterprises. The study was carried out following a procedure based on a qualitative methodology, which makes it possible to identify indicators related to sustainable forest management processes, applicable at national and international level (Martinez et al., 2020b). These authors formulate, codify and categorise a set of four criteria and formulate a set of twenty-seven indicators for sustainable forest management, and develop a causal relations map (Martinez et al., 2020b). The criteria groups are as follows: Criterion I: Existence of conditions for excellence-oriented forestry management; Criterion II: Establishment, maintenance and conservation of the integrity of the forest ecosystem; Criterion III: Sustainable Forest Production; Criterion IV: Strengthening and contributing to the local economy (Martinez et al., 2020b).

Table 1. Perspectives and Indicators for Management Control in Forest Sector Enterprises

Source	Perspectives and Indicators			
	Financial Perspective	Environmental Perspective	Internal Process Perspective	Strengthening and contributing to the local economy
(Martinez et.al., 2020a)	Financial Perspective	Environmental Perspective	Internal Process Perspective	
(Martinez et.al., 2020b)		Establishment, maintenance and conservation of the integrity of the forest ecosystem, Sustainable forest production, Existence of conditions for excellence-oriented forestry management		Strengthening and contributing to the local economy
(Huang, 2022)	Dimension of Financial Status	Dimension of External Environmental Risk	Dimension of Internal Governance Mechanism, Supervision and Information Communication	
(Gunn, 2003)		Biodiversity, Ecosystem Health and Productivity, Soil and Water	Multiple Benefits	Accepting Society's Responsibility, Global Cycles

According to Huang (2022), it is necessary to establish an appropriate set of indicators for prediction of unwanted large deviations in the internal control of registered enterprises in China. According to the same author, internal control is based on a system of 12 indicators, grouped into four groups: Dimension of Internal Governance Mechanism, Dimension of External Environmental Risk, Dimension of Financial Status, Supervision and Information Communication (Huang, 2022). Using the PCA (Principal component analysis) method, in order to reduce the size of the analysis of the main components, the initial 12 indicators were reduced to 3.

According to the Canadian Council of Forest Ministers (CCFM, 2000), indicators related to forest management are grouped into six criteria with 22 main elements and 83 indicators. Given the large number of indicators that are multidimensional in themselves, Gunn (2003) initially grouped them into six groups: Biodiversity, Ecosystem Health and Productivity, Soil and Water, Global Cycles, Multiple Benefits, Accepting Society's Responsibility. This author suggests making a choice of indicators (G) with an appropriate control mechanism (B). The correct choice of these indicators ensures that if the global forest system is subjected to adverse external influence, the control with the established feedback will bring it back to the desired equilibrium state. According to Gunn (2003), the control contains processes for measuring the speed of change in the average values of these indicators over time.

4. DISCUSSION

The analysis of the results of the review of the scientific literature has shown that indicators related to the environment are the most discussed. Such are those associated with the creation, maintenance and preservation of the integrity of the forest ecosystem (Martinez et al .2020), with measuring external environmental risk (Huang, 2022) and those related to biodiversity, health and productivity of ecosystems, soil and water (Gunn, 2003). To a large extent, this result stems from the nature of the subject being explored. A similar set of eco-indicators that study the environmental management practices applied in integrated farms, warehouses, chemical wastewater treatment plants, feed mills and meat processing plants are also being reviewed by Rodrigues et al. (2024). According to the same authors, these indicators can be applied also for planning and analysis of forest sector enterprises (Rodrigues et al., 2024).

Secondly placed are the indicators regarding internal control processes of forest industry enterprises. According to Huang (2022), these are related to the measurement of internal management mechanisms (e.g. production plans, the index of cost and expenses, etc.), to which we can add those associated with information management. Martinez et al. (2020) add groups of indicators related to sustainable forestry production oriented towards excellence. According to other authors, such as Adebowale (2019), performance indicators in business can be both financial and non-financial, although most of them focus on the former.

The next group of indicators is designated on the basis of the contribution to the local economy (Martinez et al., 2020) and the responsibility to society. Gunn (2003) adds to them indicators related to global cycles.

The fourth group of indicators is related to measuring the financial and economic status (Martinez et al., 2020), (Huang, 2022). According to Adebowale (2019), return on capital used, net assets, earnings per share are also performance indicators that business organisations use to determine the achievement of their goals.

According to Martinez et al. (2020) there are also qualitative indicators that measure the level of customer satisfaction and track the extent to which forest industry enterprises are progressing towards innovation in new products (Martinez et al., 2020).

The group of indicators in Table 1 for management of forest industry enterprises are contradictory from financial point of view, in terms of customer, environment and internal processes, and some of them are mutually exclusive. Martinez et al. (2020) analyse the vertical and horizontal relations between them using Pearson's bivariate correlations to establish correlation. In the horizontal relations between the indicators, according to these authors, the most correlated ones are those of the group focused on natural environment. The same authors introduce a map of causal relations that examines the balance between them to achieve the strategic objectives of forest industry enterprises (Martinez et al., 2020).

The criteria of this report are of a qualitative and quantitative nature. According to modern management theory, performance assessment based entirely on objective indicators within an organisation is not considered an effective tool (Lambovska et al., 2019). The implementation of this management concept implies the need of introduction of evaluation models combining objective (quantitative) and subjective (qualitative) indicators (Lambovska et al., 2019).

Other authors, such as Cesarotti et al. (2009) and Santolamazza et al. (2017), develop a two-tier indicators methodology for enterprises in the energy sector, on the basis of which a systematic control approach for forest industry enterprises can be developed.

As regards the tools of the four sources of this report, the results are as follows: Martinez et al. (2020) use the direct survey method. Sources using the so-called "other data collection methods" prevail. Huang (2022) optimises the parameters of the random forest through a genetic algorithm, while retaining most of the original information from the 630 company and 12 indicators studied. For data analysis Martinez et al. (2020) uses methodology and Gunn (2003) and Huang (2022) quantitative methods.

5. CONCLUSION

The specificity of the management function "control" in the forest industry stems from the need for environmental control globally. In this regard, setting indicators for management control in these organizations is important in the context of the concept of sustainable development.

This report provides a system of indicators for management control of forest industry enterprises. The study is based on publications in the Web of Science and Scopus indexed scientific databases for the period until the end of 2023. Methodologically, a systematic approach has been applied, based on four scientific publications on the studied topic.

The results of the review show that the different authors apply quantitative and qualitative indicators for management control or a combination of both types of factors.

The contribution of the report is of a theoretical nature. In terms of practice, the system of management control indicator in this report can be used to select tools in the management practice of forest industry enterprises.

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REFERENCES

1. Adebowale, O. (2019). Budget Roles and Organizational Effectiveness among Listed Manufacturing Companies in Nigeria (Doctoral dissertation, Kwara State University (Nigeria)).
2. Angelova, A. (2023). Comprehensions of Controlling in Bulgarian Scientific Literature. *Nauchni trudove*, (5), 195-205. https://doi.org/10.37075/RP.2023.5.09
3. Cesarotti, V., Di Silvio, B., & Introna, V. (2009). Energy budgeting and control: a new approach for an industrial plant. *International Journal of energy sector management*, *3*(2), 131-156. https://doi.org/10.1108/17506220910970551
4. Gunn, E. A. (2005). Sustainable forest management: control, adaptive management, hierarchical planning. *United States Department of Agriculture Forest Service General technical report PNW*, (656), 7-14.
5. Huang, Z. (2022). A Hybrid Approach for Identification of Deficiencies in Enterprise Internal Control. Wireless Communications and Mobile Computing (Online), Oxford, Vol. 2022, (2022). https://doi.org/10.1155/2022/3022726
6. Lambovska, M., Rajnoha, R., & Dobrovič, J. (2019). From Quality to Quantity and Vice Versa: How to Evaluate Performance in the Budgetary Control Process. *Journal of Competitiveness*, *11*(1), 52–69. https:// doi.org/10.7441/joc.2019.01.04
7. Martínez, J. P., Hernández, M. E. F., & de la Nuez Hernández, D. (2020A). Indicators for management control oriented towards excellence, for integral forest development, *Revista cooperativismo y desarrollo-COODES, 8*(1), 57-67.
8. Martínez, J. P., Hernández, M. E. F., & de la Nuez, D. (2020B). Criteria and indicators of forest management for excellence. *Revista cooperativismo y desarrollo-COODES, 8* (1), pp. 93-115.
9. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., & Clark, J. (2009). Preferred reporting items for systematic reviews and meta_analyses: the PRISMA statement (Chinese edition). *Journal of Chinese Integrative Medicine*, *7*(9), 889-896. https://doi.org/10.3736/jcim20090918.
10. Rodrigues, V. D. V., Wander, A. E., & da Silva Rosa, F. (2024). Indicators to analyze environmental performance and eco-controls for a poultry production chain: a methodological proposal based on the EMA system. *Environment Systems and Decisions*, *44*(1), 145-160. https://doi.org/10.1007/s10669-023-09918-x
11. Santolamazza, A., Introna, V., & Cesarotti, V. (2017). Energy budget control in manufacturing systems with on-site energy generation: An advanced methodology for analyzing specific cost variations. In *Proceedings of the Summer School Francesco Turco* (pp. 404-410). AIDI.

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IMPACT OF DIGITAL TRANSFORMATION ON AUDIT PROCEDURES IN THE ASSESSMENT OF CORPORATE SUSTAINABILITY

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Abstract: Digital transformation has a significant impact on audit procedures in the assessment of corporate sustainability. The integration of modern technologies enables the evaluation process to adapt to the tools that are applied by companies for accounting and reporting of corporate sustainability. Auditors can now use advanced analytics tools to analyze financial and non-financial data related to sustainability. Repetitive tasks such as data entry and validation can be automated, allowing auditors to focus on more complex analysis and interpretation of sustainability data.
Digital transformation has led to the development of integrated reporting frameworks that standardize how companies report sustainability information. This helps auditors assess and compare sustainability performance across organizations. Digital transformation has facilitated remote auditing capabilities. Companies can use digital platforms to engage with stakeholders and ensure transparent communication about sustainability initiatives. Auditors can use this information to gain insight into the company's relationships with its stakeholders.
The publication is aimed at research and analysis of the possibilities for optimization of audit procedures, related to assurance commitments and increasing the value of reports. The research will focus on the impact of digital transformation on audit procedures to improve the efficiency, accuracy and timeliness of sustainability audits, enabling auditors to provide more valuable information about a company's overall sustainability performance. Digital tools enable auditors to adapt quickly to changes in sustainability reporting regulations.
Keywords: digital transformation, audit procedures, corporate sustainability

1. INTRODUCTION

The advent of digital transformation has revolutionized audit procedures for corporate sustainability. By integrating advanced technologies, audits have become more efficient, equipping auditors with enhanced tools and capabilities to assess and report on corporate sustainability (Moldavska, 2017). The digital revolution has made vast amounts of data more accessible, empowering auditors to use advanced analytics tools for in-depth analysis of financial and non-financial sustainability data. Automation of repetitive tasks like data entry and validation has freed up auditors to focus on more intricate analysis and interpretation of sustainability data. Real-time monitoring of sustainability metrics is now possible, enabling auditors (Yang, Zhang, & Ye, 2024) to conduct continuous audits and provide a more up-to-date and accurate assessment of corporate sustainability performance.

Blockchain, a key player in digital transformation, is instrumental in ensuring data integrity and transparency, which are the bedrock of sustainability reporting. Auditors can rely on blockchain to verify the accuracy of sustainability data and trace its origin, thereby significantly enhancing trust in the reported information. AI and ML algorithms can be harnessed to conduct predictive analysis on sustainability trends and identify potential risks (James, 2009), aiding auditors in assessing the long-term sustainability of a corporation. Cloud-based platforms facilitate collaborative auditing, enabling auditors to work together seamlessly, even if they are geographically dispersed, thereby enhancing the efficiency and effectiveness of sustainability audits. With the increased reliance on digital platforms, auditors need to focus on cybersecurity to ensure the protection of sensitive sustainability data from unauthorized access and manipulation.

Digital transformation has led to the development of integrated reporting frameworks (Maheshkar, Jadhav, Kulkarni, & Kulkarni, 2023) that standardize the way companies report sustainability information. This standardization makes it easier for auditors to assess and compare sustainability performance across different organizations. Digital transformation has also paved the way for remote auditing capabilities, revolutionizing efficiency and cost-saving. Auditors can now access systems and data remotely, reducing the need for physical presence and associated travel costs.

Digital tools enable auditors to adapt quickly to changes in sustainability reporting regulations. They can efficiently incorporate new requirements into their audit procedures. The impact of digital transformation on audit procedures in assessing corporate sustainability is substantial. It has improved sustainability audits' efficiency, accuracy, and timeliness, allowing auditors to provide more valuable insights into a company's overall sustainability performance. However, auditors must also address challenges related to data security and stay abreast of evolving technologies and reporting standards.

2. DIGITAL TRANSFORMATION AND CORPORATE SUSTAINABILITY

In recent years, digital transformation has become a key element in corporate strategies, aiming to optimize operational efficiency and improve corporate sustainability. The transformation driven by new technologies such as artificial intelligence (AI), blockchain and big data is changing how companies conduct business and their ability to meet growing expectations for sustainable development (Sun, Li, Lu, & Guo, 2024). Sustainable development, in this context, refers to the practice of meeting the needs of the present without compromising the ability of future generations to meet their own needs. It encompasses environmental, social, and economic aspects, and digital transformation plays a crucial role in enabling companies to achieve these goals.

Artificial intelligence (AI) is a game-changer in digital transformation, particularly in the realm of corporate sustainability (Aleksandrova, Ninova, & Zhelev, 2023). Its ability to process vast amounts of data on environmental, social, and management practices provides companies with detailed insights into their societal and environmental impact. This data-driven analysis is instrumental in identifying potential risks and areas for improvement, crucial for building resilience strategies. For instance, AI systems can optimize supply chains, leading to reduced carbon emissions and enhanced energy efficiency.

Blockchain technology is a catalyst for transparency and accountability in corporate sustainability (Georgieva & Georgieva, 2024)=Its ability to create immutable and transparent records facilitates the verification of sustainable practices and ethical behaviour across the supply chain. This technology empowers companies to showcase their commitment to sustainable development and equips stakeholders with valuable data for informed decision-making. For example, blockchain can be leveraged to trace the origin of raw materials, ensuring their sustainable and environmentally friendly sourcing.

The use of big data presents a wealth of opportunities for in-depth sustainability analysis. By collecting and processing information from diverse sources, from social media to public databases and internal corporate systems (Al-Sabti, 2023), big data equips companies with a comprehensive understanding of their environmental and societal impact. This understanding is key in identifying trends and predicting potential sustainability risks. Big data analysis enables companies to make informed decisions that support long-term sustainability and corporate responsibility. Moreover, the analysis of large data volumes can facilitate the development of customized products and services that cater to the growing consumer demand for sustainability. This, in turn, can lead to increased customer loyalty, market share, and profitability.

By harnessing the power of these technologies, companies can play a pivotal role in shaping a more sustainable future. The integration of artificial intelligence, blockchain, and big data can provide a deeper understanding of sustainability and pave the way for innovative approaches to its enhancement. This digital transformation allows companies to not only optimize existing processes but also to pioneer new business models that champion sustainable development.To seize the opportunities presented by digital transformation, companies must forge comprehensive strategies that encompass technological innovation and cultural and organizational changes (Azizi, Hakimi, Amiri, & Shahidzay, 2024). Investments in employee training and development are paramount to ensure a skilled workforce capable of leveraging new technologies. Fostering an open corporate culture that fosters innovation and experimentation can equip companies to adapt swiftly to a dynamic business environment.

There is also a need to develop standards and regulations to ensure that new technologies are used ethically and sustainably. This includes mechanisms to protect data and personal privacy and standards for accountability and transparency in the use of AI, blockchain and big data. To reap the maximum benefits from these innovations, companies must implement a holistic approach that includes technological, cultural and organizational changes. However, this journey cannot be undertaken by companies alone.

3. CHANGES IN THE AUDIT PROCEDURES UNDER THE INFLUENCE OF DIGITAL TRANSFORMATION

As a result of digital transformation, it is essential to consider issues related to new technologies to optimize the processes of data collection, analysis, and assessment of corporate sustainability. Digital transformation is a catalyst for changes in many aspects of business operations, including procedures related to auditing and assessing corporate sustainability. The adaptation of new technologies in audit procedures optimizes data collection processes and offers new opportunities for analysis isignificantly improving the accuracy and objectivity of audit conclusions.

The traditional data collection process is often time-consuming and subject to human error, limiting the ability to analyze large volumes of information. Integrating AI and IoT devices automates data collection, allowing auditors to receive high-quality, accurate, and up-to-date real-time information. It provides a more complete picture of the company's operational activity and sustainability while reducing the time and resources required for the audit process. AI algorithms can process and analyze vast volumes of data, identifying patterns, trends and potential risks that may go unnoticed with traditional analysis methods. It enables a deeper understanding of the impact of business practices on the environment and society, as well as an assessment of the company's sustainability. For example, using big data and AI to analyze consumer behaviour and preferences can help companies develop more sustainable products and services that meet customer expectations and regulatory requirements.

In finance, companies use AI to analyze legal documents to identify potential risks and areas for improvement in corporate sustainability management (Sciarelli, Landi, Turriziani, & Tani, 2019). In the real estate sector, companies are applying IoT devices to monitor the energy efficiency of buildings, which helps them identify opportunities to reduce energy consumption and carbon emissions. Introducing digital tools and technologies in audit procedures leads to significant improvements in assessing corporate sustainability. For example, agrotech companies use satellite data and AI to monitor sustainable farming practices, providing evidence of sustainable resource use and biodiversity conservation. Such innovations allow auditors to perform a more accurate and comprehensive analysis of companies' sustainability while reducing the need for physical on-site inspections.In the manufacturing sector, blockchain technologies enable the traceability of materials and ensure that products are produced ethically and sustainably. Additionally, big data analytics technologies have revolutionized how auditors assess risks and resilience. Using machine learning algorithms, companies can analyze internal and external data, including social media and news sources, to gain a holistic view of the impact of their operations on society and the environment (Lambovska & Yordanov, 2020). This approach allows auditors to identify potential problems and opportunities for improvement that may have previously gone unnoticed. For financial institutions, the digital transformation of audit procedures is particularly useful in credit risk assessment and portfolio management.

Digital transformation is dramatically changing audit procedures by providing tools for more efficient and objective data collection, analysis and assessment of corporate sustainability. In this way, the audit process is optimized, and an opportunity is provided for a deeper understanding of the complex interrelationships between corporate operations and their impact on sustainability (Zhang, Chen, & Hao, 2022). It supports the development of more integrated sustainability strategies that reflect the real risks and opportunities facing businesses in a dynamic global economy. One of the critical aspects to consider when implementing digital tools in audit procedures is data protection and privacy. Auditors and their clients must ensure strict security measures and compliance with regulatory requirements to protect personal data as the volume and sensitivity of data collected increases..

Ultimately, digital transformation in audit procedures opens new doors to achieve higher corporate sustainability by providing richer insights and more effective risk management. Despite the challenges associated with adapting to new technologies and the need to protect data, the potential to improve auditing practices and increase their value to corporations is significant. Auditors who effectively integrate digital technologies into their work can provide more profound and meaningful analyses of corporate sustainability that support strategic decision-making and contribute to sustainable development. Integrating digital transformation into audit procedures presents a challenge and an opportunity for professionals in the field. It offers a chance for auditors to strengthen their contribution to corporate sustainability and play an even more critical role in supporting sustainable business development. By expanding their skills and adapting to new technologies, auditors will increase their value as professionals and contribute to creating a more sustainable future for business and society.

4. CHALLENGES AND OPPORTUNITIES FOR AUDITING PRACTICE

Digital transformation, despite its challenges, holds immense potential for the audit practice. It offers a revolutionary approach to assessing corporate sustainability, promising to reshape the way auditors operate and deliver value, ultimately leading to enhanced efficiency and effectiveness.However, the rapid pace of technological advancements can lead to resistance among auditors and their clients. To harness the benefits of these new tools, auditors must not only acquire technical knowledge but also foster a culture of innovation. This shift in mindset and work processes is crucial for auditors to stay relevant in an evolving landscape.

There is also the risk of relying on technological solutions that may not be fully understood or whose limitations may remain hidden. This underscores the crucial role of auditors in maintaining a critical eye on the tools they use and evaluating the reliability and accuracy of the data they generate. Understanding the potential intended and unintended consequences of technological solutions is paramount to upholding high standards of quality and reliability in audit work. This recognition of auditors' role in the digital era should make them feel valued and integral to the audit process.

Despite the challenges, digital transformation presents an opportunity for auditors to play an even more critical role in assessing corporate sustainability and contributing to sustainable business development. Auditors who manage to adapt to new technologies and develop the necessary skills will not only provide deeper insights but also significantly improve decision-making in the organizations they serve, making a tangible difference in the world of business.To fully harness the benefits of digital transformation, it is imperative to foster collaboration between auditors, technology providers, regulators and other stakeholders. This collaborative approach can help shape standards and best practices, ensuring the effective and responsible use of new technologies in audit practice. By emphasizing the need for collective effort, auditors can feel part of a supportive and inclusive community driving the digital transformation journey. This sense of community and shared responsibility should encourage auditors to embrace digital transformation.

5. CONCLUSION

Digital transformation is causing significant changes in auditing practice, offering opportunities to improve corporate sustainability assessment but also requiring adaptation to new skills and challenges. The balance between using innovative technologies and maintaining high standards of ethics and quality will be critical to the success of auditors in the future digitalized business environment. Digital transformation is radically changing how the operational effectiveness of internal control in companies is evaluated, especially regarding accountability and reporting under the requirements of sustainability standards. One of the fundamental directions in which this transformation is manifested is the application of new technologies for conducting audit procedures. Auditors must also be prepared to handle the challenges of interpreting data obtained through new technologies. Although automation and AI algorithms can significantly increase the volume and speed of data analysis, auditors must maintain their critical judgment and professional scepticism to ensure that the results are appropriately interpreted and applied in the context of the audit conclusions.

Opportunities for digital transformation in audit practice not only improve the assessment of corporate sustainability but also contribute to the development of more sustainable business models and practices. By overcoming challenges and effectively using new technologies, the auditing profession can play an even more significant role in promoting sustainable development and supporting companies' strategic sustainability goals.

REFERENCE

1. Aleksandrova, A., Ninova, V., & Zhelev, Z. (2023). *A Survey on AI Implementation in Finance,(Cyber) Insurance and Financial Controlling.* Risks, 11(5). doi:10.3390/risks11050091
2. Al-Sabti, A. (2023). *Implications for Enhancing the Financial Reporting Quality Brought on by the Digital Revolution of Internal Control*. International Journal of Professional Business Review, 8(4), e01381-e01381. doi:10.26668/businessreview/2023.v8i4.1381
3. Azizi, M., Hakimi, M., Amiri, F., & Shahidzay, A. (2024). *The Role of IT (Information Technology) Audit in Digital Transformation: Opportunities and Challenges.* Open Access Indonesia Journal of Social Sciences, 7(2), 1473-1482. doi:10.37275/oaijss.v7i2.230
4. Georgieva, D., & Georgieva, T. (2024). *Challenges for the accounting and reporting of research and development expenditures in Bulgaria.* TRANSNATIONAL CORPORATIONS REVIEW, 16(1), 119-134. doi:10.1080/19186444.2022.2040270
5. James, C. (2009). *Corporate Governance and Sustainability Disclosures and the Assessment of Default Risk. Asian Journal of Finance & Accounting*, 1(1), 3453-3453. doi:10.5296/ajfa.v1i1.93
6. Lambovska, M., & Yordanov, K. (2020). *Understanding 'Motivation-Internal Control'Relations in Municipalities*. TEM Journal, 9(2). doi:10.18421/TEM92-32
7. Maheshkar, S., Jadhav, B., Kulkarni, A., & Kulkarni, P. (2023). *Sustainability Reporting And Accounting By The Indian Corporates*. Journal of Pharmaceutical Negative Results, 14(1), 535-539. doi:10.47750/pnr.2023.14.S01.63
8. Moldavska, A. (2017). *Defining Organizational Context for Corporate Sustainability Assessment: Cross-Disciplinary Approach*. Sustainability, 9(16). doi:10.3390/su9122365
9. Sciarelli, M., Landi, C., Turriziani, L., & Tani, M. (2019). *Corporate Sustainability Assessment and Risk Perception: Empirical Evidences from Standard & Poor's Index*. American International Journal of Contemporary Research, 9(1), 11-21. doi:10.30845/aijcr.v9n1p2
10. Sun, Y., Li, J., Lu, M., & Guo, Z. (2024). *Study of the Impact of the Big Data Era on Accounting and Auditing*. Frontiers in Business, Economics and Management, 13(3), 4.
11. Yang, K., Zhang, T., & Ye, C. (2024). *The Sustainability of Corporate ESG Performance: An Empirical Study*. Sustainability, 16(6). doi:10.3390/su16062377
12. Zhang, C., Chen, P., & Hao, Y. (2022). *The impact of digital transformation on corporate sustainability-new evidence from Chinese listed companies*. Frontiers in Environmental Science, 10, 1047418. doi:10.3389/fenvs.2022.1047418

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SUSTAINABLE DESIGN AND CONSTRUCTION WITH FORESTRY-BASED MATERIALS

LIFE CYCLE ASSESSMENT (LCA) STUDY FOR EARLY DESIGN STAGES OF WOODEN WALL COVERINGS WITH ENHANCED AESTHETICS AND FUNCTIONALITY

Tajana Kruhak, Andreja Pirc Barčić, Domagoj Mamić,
Danijela Domljan, Darko Motik, Kristina Klarić

Abstract: As climate change, pollution, resource depletion and waste management require an urgent action on a global scale, the transition to the usage of sustainable materials and processing technologies in product design is becoming an inevitable requirement. Imposing environmental issues could be partially mitigated with transition to more sustainable materials like wood. From the numerous benefits that can be gained from wood it is important to point out its most valuable advantages such as renewability, carbon storage capacity and biodegradability. Incorporating sustainability principles into the early stages of product design is often more cost-effective and environmentally friendly than retrofitting existing products or processes. In cases such as these it is necessary to identify best available tools on the market that could back up such concepts, such as Life Cycle Assessment (LCA). LCA is a vital tool in sustainable product design that helps evaluate the environmental impact of a product throughout its entire life cycle. For the purpose of this study different versions of a product – wooden wall coverings, in its early design stages, are being analysed using LCA methodology. The goal is to present wooden products with enhanced aesthetics and functionality while offering a range of design options and environmental considerations.
Keywords: Life Cycle Assessment, product comparison, wood product design, sustainable resources, wooden wall coverings

1. INTRODUCTION

As climate change, pollution, resource depletion and waste management require an urgent action on a global scale, the transition to the usage of sustainable materials and processing technologies in product design is becoming an inevitable requirement. Global environmental challenges could be partially mitigated with transition to more sustainable materials like wood. Wood is the most extensively used biological material by humankind due to its high specific stiffness and strength (Farid et all, 2022). From the numerous benefits that can be gained from wood it is important to point out its most valuable advantages such as renewability, carbon storage capacity and biodegradability. The other advantages of wood as a material are its versatility, regarding wide range of applications, and aesthetic appeal. Wood is appreciated for its natural beauty, which can enhance the aesthetics of products, interiors and exteriors, while also promoting an eco-friendly and attractive design. Innovations in wood engineering and construction techniques are making it possible to build even taller and more durable structures than before, expanding its utilization.

Design by its very definition is a plan to show the function or workings of a place or an object before it is created (Wiking, 2022). Designers play a pivotal role in shaping various aspects of life, influencing everything from products and services to experiences, which directly manifests to our quality of life and environment. Incorporating sustainability principles into the early stages of product design is often more cost-effective and environmentally friendly than retrofitting existing products or processes. The availability of data in the early stages of product design is essential for informed decision-making, optimizing resource allocation, and facilitating continuous improvement. By leveraging data effectively, designers can create products that meet user needs, uplift business success, and mitigate negative environmental effects.

When opportunities arise, regarding data analyses in early design stages of product, it is necessary to identify the best available tools on the market that could back up such concepts, such as Life Cycle Assessment (LCA). LCA is a vital tool in sustainable product design that helps evaluate the environmental impact of a product throughout its partial or entire life cycle. Based on ISO 14040 standard, Life Cycle is consecutive and interlinked stages of product system, from raw material acquisition or generation of natural resources to final disposal. The idea of LCA was conceived in the 1960s when environmental degradation and in particular the limited access to resources started becoming a concern (Bjørn et al., 2018).

For the purpose of this study two versions of a product – wooden wall coverings, in its early design stages, are being analysed using LCA methodology. The goal is to analyse production process of wooden products with enhanced aesthetics and functionality while offering a range of design options and environmental considerations. Wooden wall coverings are a popular and versatile choice for interior and exterior wall finishes in both residential and commercial settings. They offer a range of aesthetic, functional, well-being and environmental benefits. The main characteristic of the coverings is that they are created form decorative veneer that comes from a local source. It is also important to mention that some elements of a product are made from production residue and waste materials, which is considered as a positive initiative regarding the environment.

The importance of LCA, regarding the early design process in this study, manifest itself mostly in identification of production hotspots (materials, energy and fuel consumption, transportation, and processes) which offers solid foundation for informed decision-making and early intervention which are important steps for continuous improvement.

2. MATERIALS AND METHODS

2.1. LCA of wooden products

LCA is a tool for quantifying the environmental performance of products taking into account the complete life cycle, starting from the production of raw materials to the final disposal of the products, including material recycling if needed (Goedkoop et al., 2016). Life Cycle Assessment of wooden products is a valuable tool for evaluating the environmental impact of these products throughout their entire or part of their life cycle. The most crucial ISO standards for conducting LCA assessments are 14040 and 14044 which help to ensure the credibility and reliability of LCA studies. The ISO standards entail mandatory steps such as defining Goal and Scope of the study (that also include defining functional unit and system boundaries), Inventory Analysis (data collection of all identified inputs and outputs of a product), Impact Assessment (analysis that quantifies the environmental footprint of the product) and Interpretation of results (results of the impact assessment are interpreted to identify the most significant environmental hotspots and areas where improvements can be made). Although, Life Cycle Assessment is a powerful tool for analysing commensurable aspects of quantifiable systems (Surendra and

Govind, 2013.), there are some concerns regarding methodological choices, transparency of data sources and assumptions, collaboration among stakeholders, and reliability of LCA as a decision support tool for sustainability assessment.

2.2. The aesthetic and functional aspect of wooden wall coverings

Wooden wall coverings offer a blend of aesthetic, functional, and environmental benefits, making them a popular choice for product and interior design that can contribute to the creation of inviting, comfortable, and sustainable living and working environments (Mamić and Domljan, 2023a). The main characteristic of wooden wall coverings, analysed for this study, is that their main structural composition is ash wood, and decorative aspect is assembled of either sawn or cut veneer, which gives this product and environmental but also aesthetic value. These wooden wall coverings are originally intended to be a modular element that can be combined with wooden load bearing and partition walls in sustainable building, as well as standalone products with enhanced aesthetics and functionality.

Regarding the production process of the mentioned coverings, it is important to point out that some additional aesthetics were achieved through careful selection and usage of wooden residues formed during the production of cut veneer, which is an essential part of one of the versions of the coverings (Mamić and Domljan, 2023b). The so-called "Stay-log residue" forms slats that can potentially be used in different arrangements and combinations with decorative veneer, giving numerous design options and possibilities with minimal effect on the environment. One of the main structural elements of coverings is waste material recovered from disposal site – gypsum fiberboards, that is also considered as beneficial aspect of the product.

2.3. Data gathering for LCA Inventory

One of the most demanding steps, while performing LCA assessments, is data gathering. Most of the practitioners recognise two types of data: foreground and background data. While foreground data in this case, that refer to specific data that describe our product systems, are collected directly from the product designers, production company and experts, the background data indicates the usage of databases compatible with LCA software's and various sources of literature. Most of the foreground data, on production processes, were gathered within the direct communication with production company technologists, while most of the background data, on materials (except wooden elements), energy and transport were extracted from *ecoinvent* database. Based on the Wernet et al. (2016) the *ecoinvent* database is the largest transparent unit-process LCI database worldwide. The creators of econvent database, the *Swiss centre for Life Cycle Inventories*, are ensuring the availability of high-quality environmental data worldwide to support informed sustainability decisions, which are compatible with LCA methodologies.

Since most of the product consist of wood, the data regarding production process cannot be fully precise, partially due to the ever-changing moisture content of wood and impossibility to measure exact mass of a wood that goes through each step of manufacturing process. It is also important to point out that the accuracy and quality of the gathered data largely depend on the information company provided and the validity of data available through the databases.

2.4. Functional unit and system boundaries

Wooden wall coverings, in this case, are considered relatively simple products, when observing their structure. Functional units, quantified performance of a product system for use as a reference unit (ISO 14040), for both analyses presented in this paper are 1 kg of wooden wall covering.

While product systems, collection of unit processes with elementary and product flows, performing one or more defined functions that models the life cycle of a product (ISO 14040), can be rather complex it is necessary to limit the object of study with the system boundaries. In this study, environmental impacts of wooden wall coverings are assessed trough raw material extraction, and manufacturing phase, which is a variant of LCA with cradle-to-gate approach. This approach is considered of a partial product life cycle since it excludes use and disposal phase.

2.5. Impact Assessment Methodology

LCA analyses concluded for this type of study is classified as attributive modelling. Attributional modelling is chosen when you want to know the environmental impact of a product or function and the hotspots in its life cycle, or when you want to compare the impacts of two products with the same functional unit (Goedkoop et al., 2016).

For the purpose of this study the SimaPro (version 9.3.0.3) software was used. SimaPro is a widely used LCA software developed by *PRé Sustainability*. *PRé* has been a leading voice in sustainability metrics and life cycle thinking development for nearly 30 years, pioneering the field of environmental and social impact assessment (Various authors, *PRé Sustainability*).

The method selected for LCA analysis is ReCiPe 2016 due to the wide range of characterization factors that provide comprehensive insights regarding negative effects that are displayed on global scale. The characterization factors are grouped into two impact categories: Midpoint, that is problem oriented, and Endpoint, that is damage oriented.

3. IMPACT ASSESSMENT AND INTERPRETATION OF RESULTS

3.1. Impact Assessment Results: Characterisation – Midpoint impact category

Interpreting Characterisation results at *Midpoint* level, of *a Wooden Wall Covering – Cut Veneer* (Figure 1), it is evident that the highest impact on the environment has an MDF board, followed by the process of getting cut oak veneer and gypsum fiberboard. Regarding the interpretation of Characterisation results at *Midpoint* level, of a Wooden *Wall Covering – Sawn Veneer* (Figure 2) it is apparent that the most negative effect on the environment have the process of getting oak sawn veneer, followed by gypsum fiberboard and the process of getting ash frame.

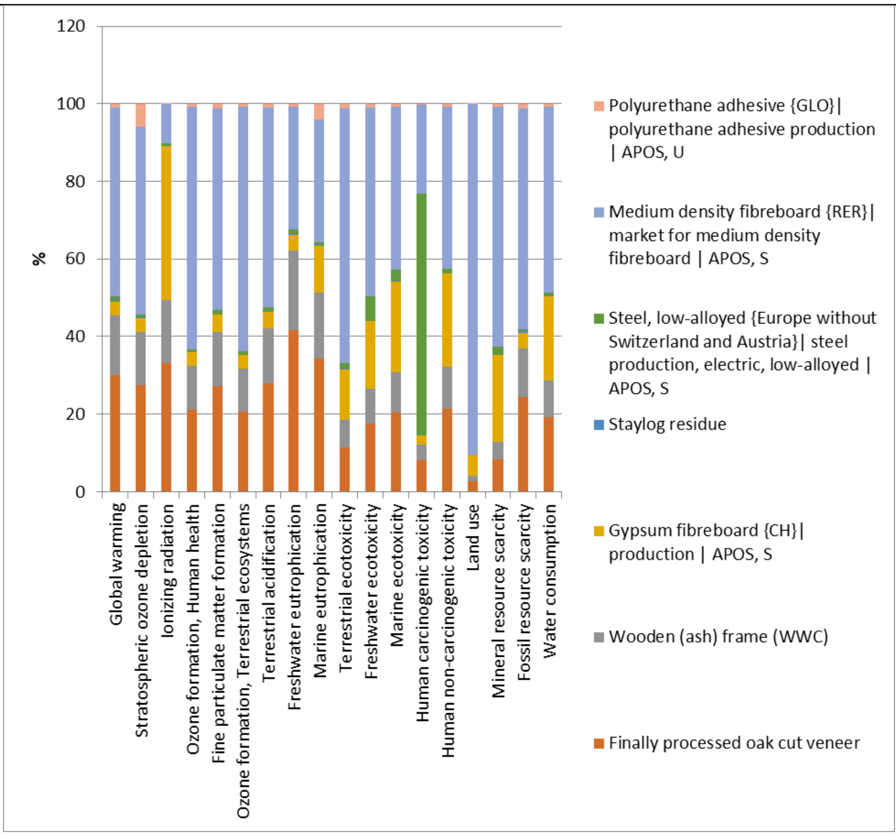

Figure 17 Characterisation results at Midpoint level - Wooden Wall Covering – Cut Veneer

3.3. Impact Assessment Results: Damage assessment – Endpoint impact category

Interpreting Damage assessment results at *Endpoint* level, of a *Wooden Wall Covering – Cut Veneer* (Figure 3), it is evident that the highest impact on human health, ecosystems and resources has an MDF board, followed by the process of getting cut oak veneer and gypsum fiberboard. Regarding the interpretation of Damage assessment at *Endpoint* level, of a *Wooden Wall Covering – Sawn Venner* (Figure 4) it is apparent that the most negative effect on the environment have the process of getting oak sawn veneer, followed by ceiling gypsum tiles and the process of getting ash frame.

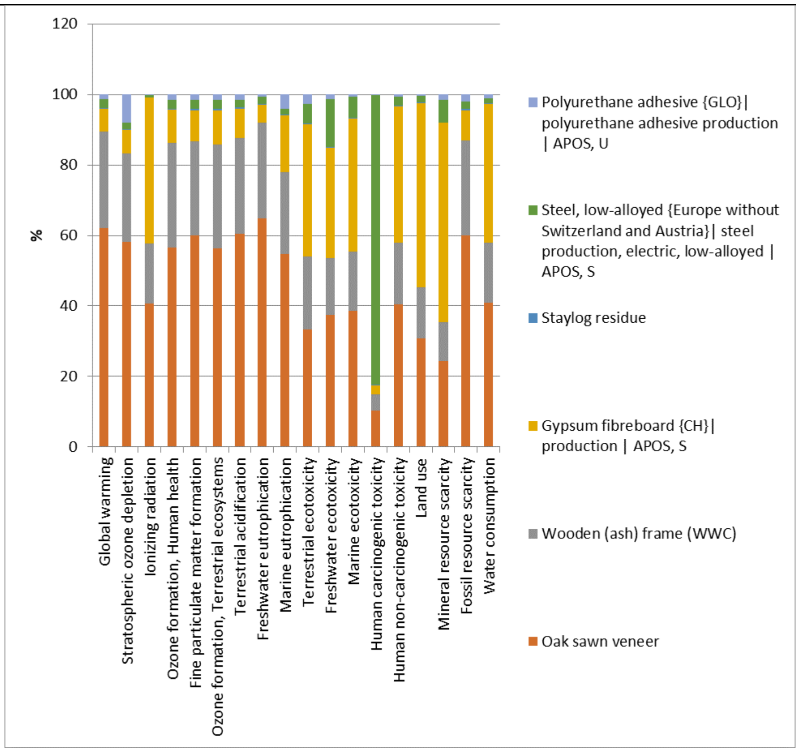

Figure 18 Characterisation results at Midpoint level - Wooden Wall Covering – Sawn Veneer

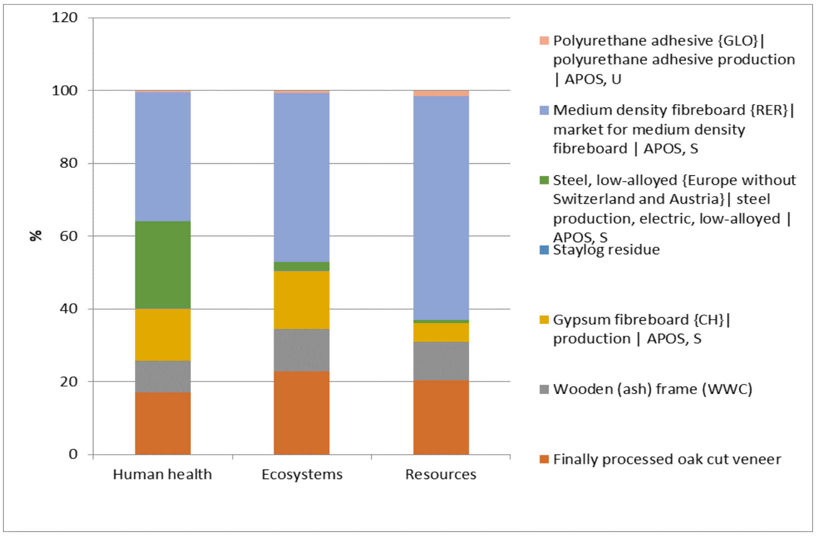

Figure 19 Damage assessment results at Endpoint level - Wooden Wall Covering – Cut Veneer

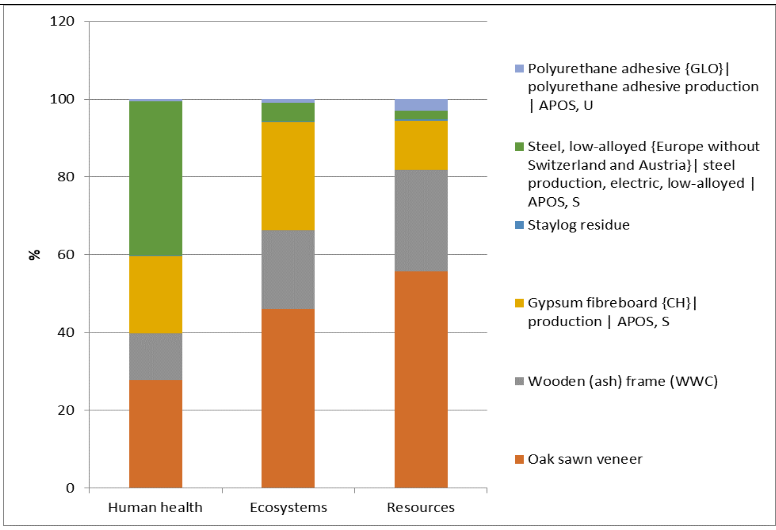

Figure 20 Damage assessment results at Endpoint level, of a Wooden Wall Covering – Sawn Veneer

4. CONCLUSION

Sustainable product design is essential for safeguarding the environment. By promoting and embracing circular economy principles in product design processes, businesses can contribute to a healthier, more resilient planet for current and future generations. Wood has the potential to be a material of the future due to its renewability, carbon sequestration capabilities, low environmental impact, versatility, biodegradability, aesthetic appeal, and positive effects on health and well-being. New technologies and innovations in wood engineering and construction are further expanding its application.

Environmental footprint calculations are essential in the early design stages of production processes for identification of environmental hotspots, informed decision-making, optimization of resource use, achieving cost savings and meeting sustainability goals. By integrating environmental considerations into the design process from the starting point, designers can create products that minimize environmental impacts and contribute to a more sustainable and resilient economy.

Wooden wall coverings can enhance the aesthetics and functionality of interior and exterior spaces while offering a range of design options and environmental considerations. When designing such products, it is highly beneficial to use a tool like LCA to help you determine so-called hotspots and implement or plan improvements in early design stages. LCA is also powerful tool for communicating the eco-friendly products and compare similar products available on the market. The eco-value of the product can be achieved through usage of renewable materials in combination with production residues and recycled materials, which was one of the main decorative and structural characteristics of wooden wall coverings in this study. Interpretation of the results has shown that both impact categories, *Midpoint* and *Endpoint*, are showing similar environmental concerns. The results presented in this study will serve as a base for a further development of a wooden wall coverings in context as a standalone product, but also as modular part of a wooden load bearing and partition walls.

Despite critiques, LCA remains a valuable tool for assessing the environmental impacts of products and processes, informing decision-making, and promoting sustainability.

Addressing LCA downsides through improved methodologies, data quality, transparency, and stakeholder engagement can enhance the reliability and credibility of LCA studies. LCA is still widely used and one of the essential tools for businesses aiming to understand and minimize their environmental footprint.

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REFERENCES

1. Bjørn, A.; Owsianiak, M.; Molin, C.; Zwicky Hauschild, M. (2018.): *LCA History. Life Cycle Assessment: Theory and practice*. Chapter 3. pp 17-30
2. Farid, T.; Rafiq, M. I.; Ali, A.; Tang, W. (2022): *Transforming wood as next-generation structural and functional materials for a sustainable future*. EcoMat: pp 1-48.
3. Goedkoop, M.; Oele, M.; Leijting, J.; Ponsioen, T.; Meijer, E. (2016): *Introduction to LCA with SimaPro. PRé* Sustainability Manual. Pp 5-5
4. ISO 14040 (2006): *Environmental management – Life cycle assessment – Principles and framework*.
5. Mamić, D.; Domljan, D. (2023a): *Design of Decorative Wooden Wall Panels from Sliced Pedunculate Slavonian Oak* (Quercus robur L.) from Veneer Production Residue. Forests, 14 (2023), 2; 414-428
6. Mamić, D.; Domljan, D. (2023b): *Positive Aspects of Using Solid Wood in Interiors on Human Wellbeing: A Review* // Drvna industrija, 74 (2023.), 3; 379-391.
7. Pacana, A.; Siwiec, D.; Bednárová, L.; Petrovský, J. (2023.): *Improving the process of product design in a phase of life cycle assessment (LCA)*. Processes Vol. 11, Iss. 9. Pp 1-32
8. Surendra, Y.; Govind, M. (2013) *Environmental Life Cycle Assessment Framework for Sukker Production (Raw Sugar Production)*. International Journal of Environmental Engineering and Management. 4 (5 (2013)): pp 499–506.
9. Various authors, *PRé* Sustainability (2020): *SimaPro database manual*. Methods library.
10. Wernet, G.; Bauer, C.; Steubing, B.; Reinhard, J.; Moreno-Ruiz, E.; Weidema, B. (2016.): *The ecoinvent database version 3 (part I): overview and methodology*. THE INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESMENT. Volume: 21. Issue9. pp 1218-1230
11. Wiking, M.: (2022): *My Hygge Home: How to Make Home Your Happy Place*. Books/Penguin Random House UK. Pp 1-278

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ASSESSMENT OF SUSTAINABLE CONSTRUCTION PRACTICES IN THE CONTEXT OF THE CIRCULAR ECONOMY

Katya Antonova

Abstract: Construction activities are among the main causes of the greenhouse effect, high consumption of natural resources, production of a huge amount of waste and energy consumption throughout the life cycle of buildings. The concept of sustainable construction has been developed for more than 30 years, applied in many countries around the world and aims to introduce sustainable construction practices related to reducing energy consumption as well as reducing climate change. The author of this article aims to present the state of sustainable construction practices in the context of the circular economy in different countries around the world and to give recommendations for the promotion of sustainable construction practices in Bulgaria.
Keywords: circular economy, sustainable construction, sustainable construction practices

1. INTRODUCTION

The challenge facing the world is ensuring a balance between economic development, improving people's well-being and preserving nature. Over the next 40 years, global consumption of materials such as biomass, fossil fuels, metals and minerals is expected to double (OECD, 2018), with the amount of waste generated each year increasing by 70% by 2050 (World Bank, 2018). Construction plays a particularly important role in reducing energy consumption, as well as reducing climate change and adapting to its effects. Construction has a significant impact on a number of sectors of the economy, local employment and quality of life. It uses huge amounts of resources (about 50% of all extracted materials), generates over 35% of the total waste in the EU (Eurostat, 2020) and about 12% of total national greenhouse gas emissions, which can be reduced by around 80% if materials are used more efficiently (Hertwich, E. end al, 2020). The author of this article aims to present the state of sustainable construction practices in the context of the circular economy in different countries around the world and to give recommendations for the promotion of sustainable construction practices in Bulgaria.

2. CIRCULAR ECONOMY

In order to respond to challenges in recent years, thinking has focused on the development of the circular economy model, which implies extending the life cycle of products. When they reach the end of their life, the materials of which they are composed can be reused so as to minimise waste disposal (B. Geldermans, M. Tenpierik, P. Luscuere, 2019). Over the next 40 years, global consumption of materials such as biomass, fossil fuels, metals and minerals is expected to double (OECD, 2018), with the amount of waste generated each year increasing by 70% by 2050 (World Bank, 2018). Morlet (2016) is of the opinion that the circular economy aims to streamline the flow of materials, information, labour and energy in such a way that social and natural potential can be restored, and Blazek (2020) defines it as "a free online market that helps to make more efficient use of currently free production factors with economic, environmental and social benefits". The circular economy is a model of production and consumption that minimizes waste and extends the life cycle of products. When the product reaches the end of its life, it is possible to recycle the materials from which it is made and used in another way (European parlament, 2023). The circular economy provides essential alternatives to reduce resource dependence by developing innovative business models for cooperation in different areas (sectors) and building closed loops that cover the production, consumption, recycling and reuse of materials. Unlike the linear (traditional) model of the economy (Fig. 1), where there are even practices for incorporating defects in appliances, to occur after a certain time or after a certain number of cycles in their use, as well as the materials and raw materials used to be consumed and discarded, the circular economy model (Fig. 2) relies on a longer product lifetime and large quantities of cheap and affordable materials and energy sources.

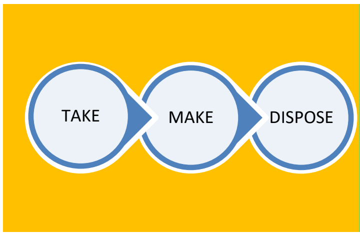

Fig. 1. Linear Economy

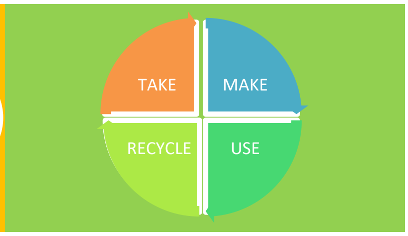

Fig. 2. Circular Economy

Timmermans (EC, 2023) is of the opinion that the circular economy is "necessary to achieve climate neutrality by 2050, protect the environment and strengthen economic competitiveness". He says that currently only 12% of the used secondary raw materials are returned to production, and there is a huge potential to reuse them.

One of the sectors where the needs of people and society and economic interests meet is the Construction sector. New construction technologies lead to a certain degree of disturbance of the balance in nature. The rate of depletion of non-renewable resources is increasing. Climate change and global warming are occurring, which is a consequence of environmental pollution, including air, water and soil. With the current adverse trends in the state of the environment, an environmentally sound development of construction and the economy as a whole is necessary and the optimal balance between objectives and interests is ensured.

The European Green Deal (2019) announced an initiative to fully modernise the construction sector in line with the principles of the circular economy. Opportunities are sought to improve efficiency throughout the life cycle of buildings and recover construction waste during demolition. One of the initiatives in this regard is the introduction of a comprehensive strategy for a sustainable built environment that promotes the application of circular economy principles throughout the life cycle of buildings. This can be achieved by:

- introduction of requirements for sustainability of construction products, incl. and requirements for the content of recycled materials in certain construction products, taking into account their functionality and safety (Regulation (EU) No 305/2011);
- promoting measures to improve the adaptability and durability of building assets in line with circular economy principles related to building design and the development of digital building logs (EU, 2022);

- promoting measures to reduce soil sealing, remediation of contaminated or derelict sites, etc.

The Action Plan to Promote the Circular Economy (European Commission, 2023) draws attention to sectors that use a lot of resources and focuses on design and production where the raw materials used remain as long as possible in the economy. It also focuses on the production of plastics, textiles, electronics, communications, etc. and introduces new rules on the use of packaging, for which 40% of the plastic and about 50% of the paper are consumed. The Plan proposes measures for the entire life cycle of products, with the aim of improving the economy, increasing competitiveness, while protecting the environment and empowering consumers. The Construction sector is considered one of the main polluters and in this sense the introduction of sustainable construction technologies and practices is imperative.

3. SUSTAINABLE (GREEN) CONSTRUCTION PRACTICES

Green building is a system of practices and technologies that aim to reduce the negative impact of construction activities on the environment. While in standard construction short-term economic objectives are relevant, for sustainable construction are a priority: (1)long-term economy; (2) minimum energy intensity; (3) minimum water intensity; (4) quality and efficiency; (5) the provision of better comfort and a healthy environment for the occupants of buildings; (6) safety and security; (7) reduce environmental pollution; (8) aesthetic appearance the spaces for habitation; (9) use of passive architectural methods; (10) entry into the architectural ensemble of the medium; (11) maximum possibility of reuse of the input materials; (12) use of renewable energy sources; (13) An opportunity for improvement through reconstruction etc.

Green activities have a different presence on the market, but the research done (World Green Building Trends, 2018, 2021) shows that companies employed in the construction sector are gradually beginning to perceive them as necessary. World Green Building Trends is a survey that has been conducted several times from 2008 to 2021, and the number of countries that are included in this study on the development of green activities is increasing many times. Countries from Europe, America, Asia and Africa take part. From the study it is clear that emerging economies such as Brazil, India, Saudi Arabia and South Africa are drivers of green growth. The results show that the expansion of green activities in construction continues in developed countries such as the US, Germany and the UK. In the survey conducted in 2018. (World Green Building Trends, 2018) also participate UAE, Spain, Norway, Ireland, Canada. According to the data in Table 1, the expected growth is largely due to countries that are still developing green-building activities. Developed markets in the US and Europe report moderate levels of growth. In contrast, respondents from Mexico, South Africa, Australia, The UAE, Spain, Norway and Ireland reported much higher growth in the percentage of their green projects. Construction companies surveyed in the 2021 survey that plan to more than:

- 40% of their projects are green Brazil (42%), United States and Singapore (45%), Colombia (46), China (47%), Canada (48%);
- 50% of their projects are green Ireland and Mexico (54%), India (55%);
- 60% of their projects are green South Africa and Spain (61%), Australia and Norway (64%), OAU (66%).

More than 200 respondents from 41 countries took part in the 2021 Global Green Building Trends Survey. In Fig 3 is presented information about the realized in 2021. Green activities and the intentions of respondents to implement green activities by 2024.

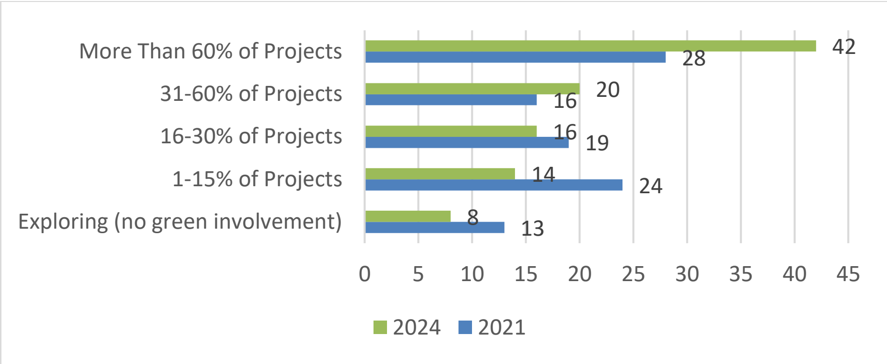

Fig. 3. Level of Green Building (According to all Respondents)
Source: World Green Building Trends, 2021

The data shows that the intentions of construction companies to implement over 60% green projects are 14% more in 2024 compared to 2021. The activities for which investments are envisaged until 2025 can be conditionally divided into eight groups: (1) New Commercial Construction; (2) New Institutional Construction; (3) New Low-rise Residential; (4) New Hige-rise Residential; (5) Existing Buildings/ Retrofit; (6) Commercial Interiors; (7) Horizontal Infrastructure; (8) Communities (tabl. 1).

Table 1. Green activities are planned by 2025.

Green activities	US/ Canada	Europe	Latin America	MENA	ASIA
New Commercial Construction (%)	14	25	22	21	25
New Institutional Construction (%)	18	21	9	21	11
New Low-rise Residential (%)	14	5	11	10	8
New Hige-rise Residential (%)	11	11	8	12	13
Existing Buildings/ Retrofit (%)	20	16	22	12	14
Commercial Interiors (%)	12	11	11	7	14
Horizontal Infrastructure (%)	2	0	0	2	2
Communities (%)	9	11	17	15	13

For problems facing investments in green projects, the surveyed companies indicate: (1) Higher initial costs - the US (73%), Ireland (68%), Colombia (58%), Australia (57%), Norway (55%); (2) Accessibility - Australia (42%), Norway and the UAE (41%), the UK (39%), China (38%); (3) Lack of support from the state, incl. government regulations and financial incentives - Colombia (49%), Spain (45%), Brazil (44%), Vietnam (41%), China (39%); (4) Lack of public awareness - India (50%), Poland (46%), UAE (45%), Spain (42%), Vietnam (37%).

Companies participating in the study (World Green Building Trends, 2018) were asked to rank sixteen factors that influence the decision to implement a green project. In the top five places, respondents indicated: customer requirements (34%); environmental regulations

(33%); ensuring a healthy living and working environment (27%); market requirements (25%) and lower operating costs (23%).

Modern technologies and new building materials allow a wide variety of opportunities for the realization of non-standard but practical ideas, both in the design and construction and reconstruction of buildings. The measures taken by surveyed Bulgarian enterprises include mainly explanatory work - 35% and discussion of the opportunities for the implementation of green projects - 33%. The role of the state in improving the overall energy efficiency of buildings is highly appreciated - 36%.

In this sense, in accordance with the Energy and Climate Integrated Plan 2021-2030. (Council of Ministers, 2020), the definition of measures for modernization of the building stock with elements of green building in Bulgaria are mainly in terms of determining cost-effective approaches to improving the energy performance of buildings through: (1) energy saving measures, including measures for the construction of the building and the building installation; (2) measures for the recovery of energy from renewable sources and the recovery of waste heat; (3) passive measures.

According to the National Integrated Energy and Climate Plan 2021-2030. (2020) by 2050, 60% of the residential building stock and nearly 17% of the non-residential stock will be renovated in Bulgaria. The area of the renovated buildings from the entire building stock will be over 45% (state and municipal non-residential buildings represent only 29% of the non-residential building stock).

Table 2. Indicators and milestones for renewal of residential and non-residential buildings in Bulgaria

Indicator		2021-2030	2031-2040	2041-2050
Energy saved total	GWh	2 917	6 502	7 329
Residential buildings	GWh	2477	5694	6294
Nonresidential buildings	GWh	440	808	1035
Renovated area	m2	22 203 509	49 570 668	55 823 015
Residential buildings	m2	19 026 656	43 735 175	48 343 297
Nonresidential buildings	m2	3 176 852	5 835 493	7 479 718
Renovated area of the existing building stock at the moment	%	8%	18%	20%
CO2 emission savings	Tone	1 306 435	2 891 610	3 274 453
Residential buildings	Tone	1 065 184	2 448 461	2 706 441
Nonresidential buildings	Tone	241 251	443 149	568 012

Source: National Integrated Energy and Climate Plan 2021-2030, 2020

CONCLUSION

The priorities of Bulgarian construction enterprises with attitudes to investing in green building are as follows: (1) Providing energy-efficient sources in buildings (50%); (2) Use of environmentally friendly raw materials (44%); (3) Use of recycled raw materials (39%); (4) Use of renewable energy sources in buildings (33%).

In order to ensure favourable conditions for investment for the construction of new and for the renovation of existing buildings and maintenance of infrastructure, it is necessary to: (1) Adopt the good practices of the countries where green building methods are applied; (2) The development of financial instruments and procedures for the renovation of buildings; (3) Improving the possibilities for auditing and assessing the energy performance of existing buildings and simplifying the administrative procedures for obtaining permission for their renovation.

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REFFERENCES

1. Blazek, L., The Future Of Shared Economy İn The Economic System. In Margarethe Überwimmer, Robert Füreder, Michael Schmidthaler, Markus Vorderwinkler. Cross-Cultural Business Conference 2020. 1. Vyd. Düren: Shaker Verlag, 2020. S. 219-232, 11 S. Isbn 978-3-8440-7301-0.
2. Geldermans, B., M. Tenpierik, P. Luscuere (2019) *Circular and flexible infill concepts: integration of the residential user perspective*, Sustainability 11 (1)
3. https://www.europarl.europa.eu/topics/bg/article/20201119STO92005/ustoychiv-model-na-potreblenie-parlamentt-nastoiava-za-pravo-na-popravka, 17-01-2024
4. Integriran plan v oblastta na energetikata I klimata 2021-2030, MS, 2020, https://www.me.governmment.bg/files/useruploads/files/
5. Morlet, Andrew, Et Al. Intelligent Assets: Unlocking The Circular Economy Potential. Ellen Macarthur Foundation, 2016, 1-25.
6. OECD (2018), Global Material Resources Outlook to 2060
7. Timermans, F., https://ec.europa.eu/commission/presscorner/detail/bg/ip_20_420
8. USGBC Partners with Dodge Data to Release World Green Building Trends 2021 Report | U.S. Green Building Council
9. World Bank (2018 г.), What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
10. World Green Building Trends 2018 - Developing Markets Accelerate Global Green Growth Smart Market Report (2018), www.construction.com/market_research.

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ENVIRONMENTAL IMPACT OF USUALLY SELECTED BUILDING FOUNDATIONS

Dominika Búryová, Pavol Sedlák

Abstract: Sustainability in the construction industry has recently come more and more to the fore and brings a conscious approach to construction and a positive impact on the environment.
The article focuses on the evaluation of usually selected building foundations in terms of climate change; acidification; eutrophication; photochemical oxidation; depletion of abiotic elements and fossil fuels; and water scarcity categories within the system boundaries of the Product of the life cycle.
The evaluation was performed using the Environmental Product Declaration for the materials used by producers.
The foundations of light wooden structures using ground screws (deep foundations) are technically and technologically faster than the commonly used flat foundations of masonry structures. The results showed that the environmental footprint of selected deep foundations is much smaller.
Keywords: foundation, ground screw, permanent formwork blocks, LCA, EPD

1. INTRODUCTION

Sustainability is a direction that is inevitable for achieving carbon neutrality and the future of our planet. EPD processing for construction products is a positive trend in the sustainability of construction.

Environmental product declarations (EPDs) according to ISO 14025 are increasing in public awareness. EPDs provide a sound basis for the communication of environmentally relevant information on a product based on LCA (Schmincke and Grahl 2007).

Nowadays, EPD is even more a tool to communicate credible information about the environmental performance of products, and program harmonization is still a key issue to be managed to broaden its application (Del Borghi, 2013).

Often, we pay attention mainly to what is visible immediately. The influence of things not directly observable is sometimes neglected. We pay attention to the visuals of the buildings, and the foundation of the buildings is in the background.

New construction, reconstruction and modernization in the Slovak Republic increased by 4.4% year-on-year, according to the report of the Statistical Office of the Slovak Republic from February 2024.The article is devoted to the comparison of the most used foundation structures for family houses. Impact categories help us understand how a product impacts our environment.

The Green Deal is the EU's strategy for achieving its goal of climate neutrality by 2050. The construction industry creates a non-negligible footprint on the environment through its activities. Clearly identifying and eliminating environmental impacts represents the future.

An important question is to show who is the primary link in the design of sustainable buildings? Usually, this character is the designer. The designer needs correct information for a reliable, safe decision-making process. The designer performs project activities and is responsible for the correctness and completeness of the documentation.

2. MATERIALS AND METHODS

The simulated object is a one-storey wooden building with a vapor permeable external envelope.

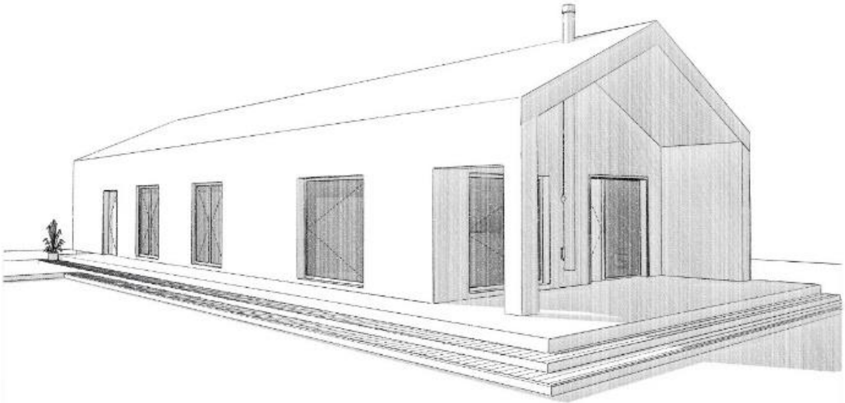

Figure 21: Visualization of a simulated house.

The assessed house is located in the 3rd (medium) temperature region of Slovakia. All types of foundations are dimensioned according to static, structural and thermal-technical equirements.

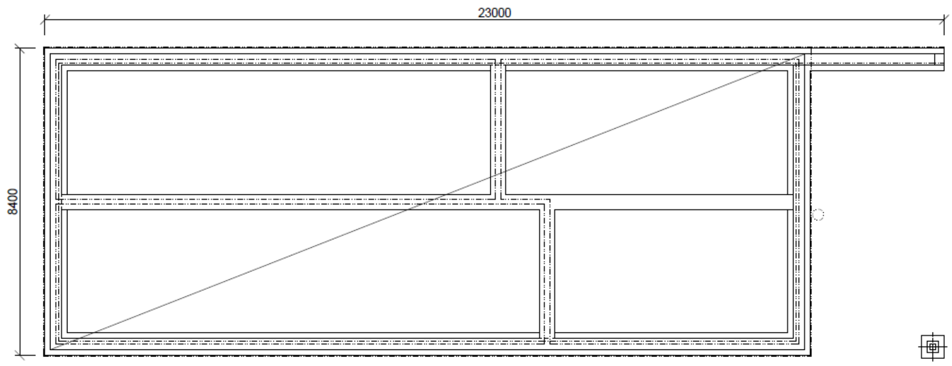

Figure 22: Floor plan of the foundation structures - the most used flat foundations.

The object of the research was the basic structures of a family house. The selected types of foundations present different ways of final realization.

Variations of basic constructions: traditional method of foundation concrete foundations-flat foundations, modern method of foundation - Ground screws, hybrid method of permanent formwork blocks.

The Permanent formwork blocks presents a combination of assembled and monolithic foundations. The low weight of wooden buildings makes it possible to use the foundation with ground screws. The ground screws are more friendly to nature, especially in the way and speed of planting in the terrain.

The following table shows selected bases with real quantification of materials.

Table 1: Material composition and weight distribution with the construction - the commonly used flat foundations and - the modern deep foundations.

	m3		pieces
ACTUAL BUILT-IN VOLUME/WEIGHT OF MATERIAL	46,095	ACTUAL BUILT-IN VOLUME/WEIGHT OF MATERIAL	30
CONCRETE FLAT FOUNDATIONS		**GROUND SCREWS**	

Table 2: Material composition and weight distribution with the construction - the most used flat foundations

	tons		m3
ACTUAL BUILT-IN VOLUME/WEIGHT OF MATERIAL	10,322	ACTUAL BUILT-IN VOLUME/WEIGHT OF MATERIAL	29,77
PERMANENT FORMWORK BLOCKS		**CONCRETE FOR FORMWORK BLOCKS**	

The Life Cycle Assessment (LCA) is evaluated based on available Environmental Product Declarations (EPD), using the "cradle-to-gate" method, for the Product stage A1 - A3.

2. RESULTS AND DISCUSSION

The choice of materials in construction is influenced by various criteria. The most common criterion is price in relation to performance. This criterion is understandable and still accepted. However, from the point of view of the sustainability of construction and with the increasing pressure to reduce the carbon footprint or waste production, it is important to consider criteria such as CO_2 production, recycling, and reuse options.

The ground screw is an ecological alternative to concrete, with many additional advantages. Ground screws are ideal for building foundations in sloping or hard-to-reach areas. Their assembly does not require water or access to a source of electricity. In the case of building on a sloping plot, it is not necessary to dig foundations or level the terrain. The necessary plane can be created by using ground screws, to which wooden beams of different lengths are attached in a vertical position.

Table 3: Quantification of environmental impact for selected foundations.

		PRODUCT STAGE A1-A3		
		CONCRETE FLAT FOUNDATIONS	GROUND SCREWS	PERMANENT FORMWORK BLOCKS
Parameter	***Unit***			
GWP (Global warming potential)	kg CO_2 eq	15676,2834	1977	10452,2834
Acidification potential of soil and water	kg SO_2 eq	59,789612	7,59	39,056862
Eutrophication potential (Eutrophication)	kg PO_4 eq	27,6130588	1,38	17,9813088
Formation of Photochemical ozone (Photochemical oxidation)	kg NMVOC	1018,725821	144,3	657,9433211
Ozone layer depletion (Depletion od stratospheric ozone layer)	kg CFC 11 eq	0,000437082	0,000087	0,000285096
Abiotic depletion potential for non-fossil resources	kg Sb eq	0,020790276	0,036774	0,013460351
Abiotic depletion potential for fossil resources	MJ	5219,27064	1299	5191,32224

Table 4: Quantification of environmental impact for separate permanent formwork blocks without concrete filling (Product Stage A1- A3)

		PERMANENT FORMWORK BLOCKS
Parameter	***Unit***	
GWP (Global warming potential)	kg CO_2 eq	9,26E+02
Acidification potential of soil and water	kg SO_2 eq	1,25E+00
Eutrophication potential (Eutrophication)	kg PO_4 eq	4,17E-01
Formation of Photochemical ozone (Photochemical oxidation)	kg NMVOC	2,63E-02
Ozone layer depletion (Depletion od stratospheric ozone layer)	kg CFC 11 eq	7,94E-06
Abiotic depletion potential for non-fossil resources	kg Sb eq	9,36E-05
Abiotic depletion potential for fossil resources	MJ	5,14E+03

Tab.4: For a comprehensive picture of the lower environmental impact of PFB, it is necessary to point out the higher degree of prefabrication, but the remaining still huge degree of monolithic works.

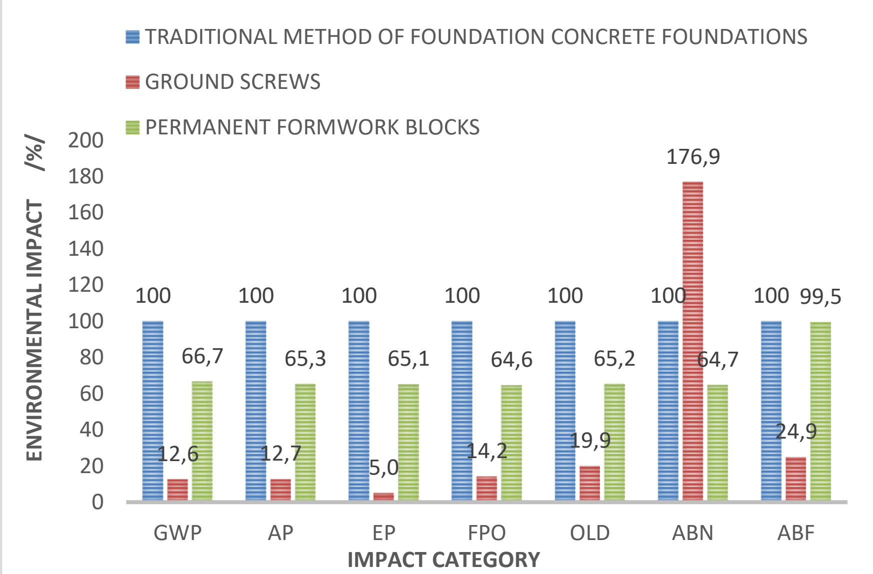

Figure 23: Environmental impact for selected bases in percentage. Abbreviations used: GWP (Global warming potential), AP (Acidification potential of soil and water), EP (Eutrophication potential (Eutrophication)), FPO (Formation of Photochemical ozone), OLD (Formation of Photochemical ozone), ABN (Abiotic depletion potential for non-fossil resources), ABF (Abiotic depletion potential for fossil resources).

Pig iron is produced in blast furnaces by reducing iron ores with carbon monoxide or carbon at high temperatures. Steelmaking is the process of making steel from iron ore or scrap (recycling process). And this fact is delayed in the ABN category. Although the amount of embedded ground bolt material itself is low, the resources are limited and localized. Steel production itself is an energy-intensive complex process.

The transfer and processing of underground fossil fuels destroys the landscape, the ecosystem and creates a lot of waste. Non-renewable energy comes from resources that are exhaustible and cannot be renewed Fig.3 shows almost the same environmental impact on the depletion of fossil resources with a different amount of embedded material for both types of concrete foundations.

It is necessary to transform the nervousness from the exhaustion of limited fossil energy sources into concrete steps in practice.

For the future positive increase of processed EPDs, the development of general guidelines regarding the management of schemes and the application of LCA is necessary. Different requirements for different EPD schemes can in practice lead to trade barriers on the construction market of EU countries and the world.

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REFERENCES

1. DEL BORGHI, Adriana. LCA and communication: environmental product declaration. *The International Journal of Life Cycle Assessment*, 2013, 18: 293-295.
2. ***: Environmental Product Declaration for Ground Screws, American ground Screw,United States and Canada Inc., [online], Issue date 12.05.2023 with 5-year validity, URL: *https://americangroundscrew.com/*
3. ***: Environmental Product Declaration for ready-mixed Concrete, ECOPact, The Green concrete, Chicago,IL, Issue date 07.16.2021 with 5-year validity, URL: *https://holcim.us/*
4. ***: Environmental Product Declaration for formworks blokcs, Danskbeton, Blokforeningen, Danmark, Issue date 15.03.2021 URL: *https://echa.europa.eu/*
5. ***: EN15804+A2 Sustainability of construction works. Environmental Product Declarations. Core rules for the product category of construction products. Level of incorporation EN 15804:2012+A2:2019
6. ***: ISO 14025:2010 Environmental labels and declarations. Type III environmental declarations. Principles and procedures
7. ***: Slovak Statistics and Demography, report on Housing construction in the 4th quarter and for the year 2023 URL: *https://slovak.statistics.sk/*

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THE CHALLENGES OF RE-USE OF WOOD IN BUILDING CONSTRUCTION IN MACEDONIA

Marija Miloshevska Janakieska

Abstract: As the circular economy becomes the focus of many EU policy programs, the re-use of different construction materials is becoming more and more important, especially in the building sector. Wood has stood the test of time as one of the earliest materials employed in architecture throughout ancient history. The utilization of reclaimed wood is driven by factors such as environmental advantages, distinctive aesthetics, historical significance, and a commitment to sustainability.
Macedonia is making efforts to promote building sustainability and circular economy, while at the same time focuses on the strategic goals related to the catalysis of green industry and green production, which is included in the new industrial strategy 2018-2027. An integral aspect of this approach centers on the mindful repurposing of materials, with a particular emphasis on their reuse in building construction.
This paper aims to investigate the challenges for re-use of some building materials in Macedonia, with the focus on the wood.
Keywords: re-use, wood, Macedonia

1. CIRCULAR ECONOMY IN BUILDING CONSTRUCTION

In circular economy (CE) the products are used again and again, which contributes in cutting down CO_2 emissions, reducing waste, and postponing the needs for new materials [6].

Nevertheless, realizing these advantages demands involving stakeholders throughout the value chain in the transformation of behavioral and social systems. It also includes designing industrial economic and production systems that facilitate, embrace, and endorse circularity within the system [9]. Circular economy (CE) stands as a crucial policy objective in Europe, making sustainability and life cycle thinking progressively focal points of attention [3, 4].

The European construction sector pointed out the importance of reducing the operational energy consumption in order to lower the negative effects of the buildings on the environment, which is huge. However, as buildings are improving their energy efficiency following the new standards, the environmental impacts associated with the phases of production, construction, maintenance, and depositing building materials represent a growing part of a building's overall environmental foorprint. Following this trend, Circular Ecomomy (CE) is aknowledged as a cruical method in sustaining the efforts for decreasing the negative environmental burdens of buildings [5]. Therefore, using the principles of CE in the construction sector is highly reccomended.

1.1. The re-use in circular economy

When it comes to the circular economy a framework is applied based on 10 common strategies for achieving it, i.e. recover, recycling, repurpose, remanufacture, refurbish, repair, re-use, reduce, rethink, and refuse. Figure 1 shows these 10 common strategies.

Smarter product use and manufacture	**R0**	**Refuse**	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1	**Rethink**	Make product use more intensive (e.g. through sharing products or by putting multi-functional products on market).
	R2	**Reduce**	Increase efficiency in product manufacture or use by consuming fewer natural resources
Extend lifespan of product and its parts	**R3**	**Reuse**	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function
	R4	**Repair**	Repair and maintenance of defective product so it can be used with its original function
	R5	**Refurbish**	Restore an old product and bring it up to date
	R6	**Remanufacture**	Use parts of discarded product in a new product with the same function
	R7	**Repurpose**	Use discarded products or its part in a new product with a different function
Useful application of materials	**R8**	**Recycle**	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9	**Recovery**	Incineration of material with energy recovery

Figure 1. CE strategies, from Potting et al. (2017) – colours modified. [7]

Reuse refers to the practice of utilizing an item, product, or component again for its original purpose or repurposing it for a different use, thereby extending its lifespan and preventing it from being discarded as waste. In the context of sustainability and environmental conservation, reusing items helps reduce resource consumption, minimize waste generation, and contribute to a more efficient and sustainable use of materials.

1.2. Relation between wood and circularity

Timber is one of the oldest construction materials. It was used in the past and it is still used today. Furthermore, the contemporary engineered wood products are receiving bigger acknowledgement within the frame of the Circular Economy as environmentally friendly and sustainable alternatives suitable for new construction, renovations, interior design, furniture, and various innovative applications. The engineered wood products possess the ability to effectively capture substantial amounts of carbon, which helps in the process of reuse and recycle in different stages of their lifespan. Therefore, it is expected the wood products to have an important role in the decarbonization efforts of the building sector and other industries. Figure 2 illustrates material flows in the forest-based sector as potential opportunities for circular practices.

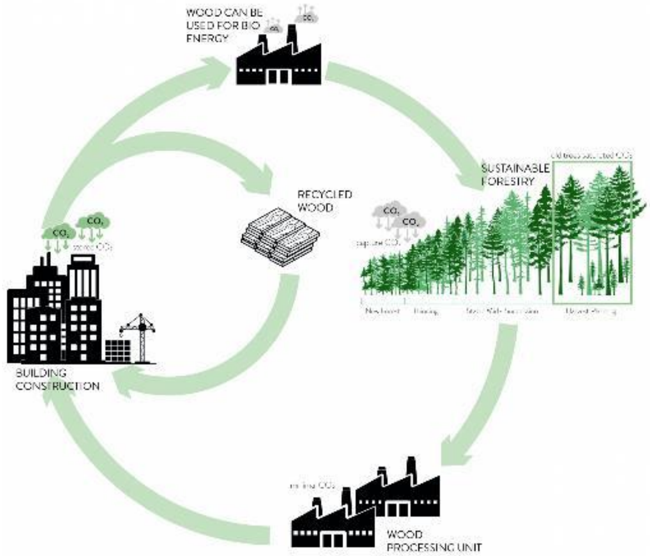

Figure 2. Circularity of wood [1]

2. RE-USE OF WOOD IN BUILDING CONSTRUCTION IN MACEDONIA

North Macedonia is aligning with the current trends in the circular economy. One project is Bio-hack My World in Skopje, which includes establishing a biohacking laboratory to engage communities in creating durable solutions to the biowaste management challenges in North Macedonia. The laboratory will leverage biowaste as a catalyst to promote innovation, education, and community involvement in addressing the growing environmental challenges within the country. By offering essential equipment, the biohacking laboratory aims to empower innovators, entrepreneurs, students, and educators to explore the possibilities of biowaste through experimentation, learning, and testing of ideas and social innovations [10].

The re-use of products and materials is becoming important in Macedonia, which strives to keep up with the latest examples in the circular economy in developed countries. This is especially emphasized in the construction sector. Many materials are reused in the building construction in the country.

Steel is often used in buildings in Macedonia, especially as a structural material for columns, beams and trusses in the frame structural system, as well as for the production of reinforcement in the reinforced concrete. Steel recycling dates back to the Roman Empire, when soldiers collected military items left on the battlefield and used them to make new weapons. Namely, steel can be endlessly transformed into new products without losing quality. Rebars, wires and various metal profiles are mostly made from recycled steel in Macedonia.

In addition, concrete is also a widely used material. Recycling concrete reduces a significant amount of construction waste, construction costs, but also reduces the amount of CO_2 emissions when creating new concrete. A special machine - crusher is used to recycle solid concrete, which is used to produce a material known as "recycled aggregate". Until recently, recycled concrete was used only for the production of foundations and slabs, but tests have shown that concrete aggregate with efficient technologies can provide structural elements of 30 to 40 MPa. It is also very important that recycled aggregates are 10 to 15 percent lighter than "original" concrete, which means less volume per cubic meter of structure, as well as lower cost for transportation.

Expanded polystyrene, commonly known as Styrofoam, is also recyclable. This material can be used for the production of new plastic products and also for the production of coatings and paints.

The use of "recycled wood" has become extremely popular in recent years. Solid recycled wood can be used for making larger structural elements or it can be used in a shape of slats for production of crates, pallets or carriers for various purposes. This wood can also be used to make formwork for the reinforced-concrete structural elements, which can be applied over and over again on construction sites, which also contains the concept of re-use.

Softer wood, which is often cheaper, can also be recycled and is often used for production of different panels. Moreover, recycled wood is also often used to make medium-density fiberboards (MDF boards).

Another element made from recycled wood is wall decorative Wood-Plastic Composite panel – WPC. WPC decorative panel is a new type of environmentally friendly product that is made from recycled wood and plastic powder. The product has the natural color of wood, but also has the durable characteristics of polymer materials. It has many advantages such as waterproof, resistant to wood-attacking insects and parasites, UV-resistant, acid and alkali resistant, abrasion and scratch resistant, no need to paint and recyclable. It also has a long service life, no corrosion, no cracks, no deformation, no waste, no maintenance, large load capacity and so on. Moreover, the product has beautiful appearance, simple installation, convenient maintenance, time and labor saving, high efficiency and can meet various needs of customers. It is used as a wall decoration in the interior design, as shown in Figure 3 [11].

Figure 3. WPC panel used as a wall decoration [11]

Furthermore, the construction of eco-houses from natural materials in Macedonia has been attracting attention lately (Figure 4). In these houses, wooden window frames and wooden doors that have already been used before are applied. Instead of being thrown away as waste, they are reused as part of these new eco-houses [2].

Figure 4. Building eco-houses in Macedonia [2]

Revival and re-design of used furniture is another aspect of the circular economy that is gaining momentum in our country. "URBAN OLD" from Skopje received a Special Award for re-design of used furniture, which deserves attention not only from an aesthetic but also from an environmental point of view. Even during the selection of the pieces, the idea for something different is born. This means that a piece of furniture that has served for many years in a bedroom or kitchen, can now get a new face and a new function, while retaining its old charm [8].

Figure 5. Re-designed furniture in Macedonia [8]

If none of these processes can be done with wood, then it can be used to produce biomass.

3. CONCLUSIONS

A recent significant EU policy program is prioritizing the circular economy, advocating for environmentally sustainable methods of production and consumption. Macedonia is aligning with these trends, initiating various projects in different fields that embrace the principles of the circular economy.

There are 10 common strategies for achieving circular economy: recover, recycling, repurpose, remanufacture, refurbish, repair, re-use, reduce, rethink, and refuse.

Although the process is slow and hard, there are several examples of re-use of wood in building construction in Macedonia, such as revival and re-design of used furniture, re-application of used wooden window frames and doors, application of recycled wood as WPC wall panel etc.

REFERENCES

1. Circularity of wood. URL: https://www.bloc.nl/zerocarbonfund/cyclical-chain1-01/
2. Eco-houses. URL: https://www.fakulteti.mk/news/20112021/dimche-ackov-izgradi-ekoselo-od-kal-i-slama-a-sonuva-da-mu-podari-shuma-na-choveshtvoto
3. Husgafvel, R.; Linkosalmi, L.; Hughes, M.; Kanerva, J.; Dahl, O. (2018): *Forest sector circular economy development in Finland: A regional study on sustainability driven competitive advantage and an assessment of the potential for cascading recovered solid wood*. In: Journal of cleaner production, 181, pp. 483-497.
4. Jarre, M.; Petit-Boix, A.; Priefer, C.; Meyer, R., Leipold, S; (2020): *Transforming the bio-based sector towards a circular economy-What can we learn from wood cascading*. Forest policy and economics, 110, 101872.
5. Leonora Charlotte Malabi Eberhardt, Morten Birkved & Harpa Birgisdottir (2022) Building design and construction strategies for a circular economy, Architectural Engineering and Design Management, 18:2, 93-113, DOI: 10.1080/17452007.2020.1781588
6. MacArthur, E. (2013): *Towards the circular economy, economic and business rationale for an accelerated transition*. Ellen MacArthur Foundation: Cowes, UK, 21-34.
7. Morseletto, P.; (2020): *Targets for a circular economy.* Resources, Conservation and Recycling,Volume 153, ISSN 0921-3449.
8. Re-design of furniture. URL: https://urbanold.com/
9. Russell, J. D. (2018): *Market transformation for value-retention processes as a strategy for circular economy*. Rochester Institute of Technology.
10. Three transformational solutions to tackle climate change (2022). URL: https://www.unicef.org/innovation/stories/2021-green-shark-challenge-winners
11. Wall Decorative Panels. URL: https://ironwood.mk/

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CONTEMPORARY POLISH WOODEN CONSTRUCTION ACTIVITY IN THE CONTEXT OF THE SUSTAINABLE ENVIRONMENTAL ECONOMY MANAGEMENT

Renata Stasiak-Betlejewska

Abstract: Modern wooden buildings are characterized by a low carbon footprint and good insulating properties, thus fitting well into the assumptions of EU climate policies. Modern wooden construction materials with high parameters in terms of load-bearing capacity, durability and fire safety are successfully used not only in single-family construction, but also in multi-story buildings. Wooden modules are also increasingly used to construct public buildings, hotels, office buildings and industrial facilities. The main purpose of the research analysis presented in the paper is to identify solutions presented by Polish producers, which are a response to the needs of the process of managing sustainable environmental management.
Keywords: carbon footprint, wooden construction, sustainable environmental economy, management

1. INTRODUCTION

The beginning of the 21st century is a time when the real scale of the impact of industrial civilization and consumerism on the state of the environment and its potential effects on the planet slowly began to reach the awareness of societies. The threat of a climate catastrophe caused by greenhouse gas emissions, imbalance of ecosystems, and overproduction of waste have prompted scientists, politicians and professionals from various fields to look for new solutions. The construction sector is one of the areas of human activity that contributes most to environmental degradation. It is estimated that nearly 40% of global greenhouse gas emissions are the result of its activity. In 2020, it was responsible for emitting approximately 20 billion tons of carbon dioxide into the atmosphere, which includes both emissions related to the use of buildings and emissions related to the construction process, as well as the production and transport of construction materials. The operational carbon footprint (related to the use of buildings) constitutes approximately 2/3 of the entire carbon footprint of a building, and its size results from the demand for energy used primarily for heating, ventilation, air conditioning and lighting. The embedded carbon footprint (from the process and building materials used) accounts for the remaining 30-40% of a building's total carbon footprint. Although the energy efficiency of buildings is constantly improving, overall emissions related to buildings are constantly increasing (Potkány 2018, Ptaszyński 2023).

Wood materials used in construction are characterized by high durability and higher added value than many other wood industry products. The growing popularity of wooden houses, stimulated by the trend of reducing CO_2 emissions in construction included in the European Green Deal, creates good development prospects for producers of wooden houses. The industry is undoubtedly supported by rapid technological development in the field of modern wooden construction materials with high parameters in terms of load-bearing capacity, durability and fire safety (e.g. CLT). A stable supply of wood raw materials and rational, sustainable forest management are key to the development of the industry (Balkiewicz-Żerek 2022).

In 2022, the Global Status Report for Buildings and Construction (Buildings-GSR), as a flagship publication of the UNEP-hosted Global Alliance for Buildings and Construction (Global ABC), provides key recommendations (UN Environment Programme, 2022):

- Build coalitions of national stakeholders to set targets and strategies towards a sustainable, zero-carbon and resilient buildings and construction sector through Buildings Roadmaps. Following the Global ABC roadmaps process and model, more than 30 countries and territories have been developing roadmaps.
- National and sub-national governments must establish mandatory building energy codes and set a pathway for their building codes and standards to achieve net zero as soon as possible.
- Governments and non-state actors must increase their investment in energy efficiency.
- The construction and real estate industries must implement zero-carbon strategies for new and existing buildings.
- The building materials and construction industries must commit to reducing their CO2 emissions throughout their value chain.
- Governments, especially cities, need to implement policies that promote the shift to 'circular material economies'.
- Fast-growing countries and economies need investment in capacity-building and supply chains that promote energy-efficient designs, low-carbon and sustainable construction.

Germany, Sweden, Italy, Austria and Finland are among the largest producers of prefabricated wooden houses in the EU. Production sold on these five markets reached nearly EUR 6 billion in 2020, which constituted approximately 3/4 of production sold in the entire EU. These markets are not export-oriented, the vast majority of production meets the demand of domestic customers. The popularity of wooden construction in Western European markets is much greater than in Poland. For example, in Germany, approximately 1/5 of newly constructed buildings, both residential and non-residential, are constructed using wooden technology. In Scandinavian countries, this indicator reaches even 80-90%. Wood is also a key construction material in the US market.

Currently, Poland is one of the world's largest exporters of prefabricated wooden houses. The export value reached EUR 115.1 million in 2021, recording the largest increase in value among the top 10 exporters compared to the previous year. The leader in the ranking is Estonia, whose exports in 2021 reached EUR 475.5 million, followed by Lithuania with exports of EUR 216.2 million. The average export growth rate in 2018-2021 in the markets of the three largest exporters reached approximately 10%. Germany, Great Britain and Norway are among the largest recipients of prefabricated wooden houses from Poland, accounting for nearly 2/3 of the export value. Other important recipients are the Netherlands (13% of exports) and France (5%).

According to the Central Statistical Office in Poland (2023), buildings constructed using the wooden construction method are: frame houses (light wooden frame enclosed with beams and finishing layers), prefabricated/modular houses (prefabricated wooden elements, assembled on the construction site, whose external wall covering is finished with boards or plaster) and log houses (bales placed horizontally on top of each other). Currently, construction technology based on the so-called massive construction timber, e.g. CLT (cross laminated timber), BSH (German: Brettschichtholz, laminated construction timber) or KVH (German: Konstruktionsvollholz, solid construction timber), LVL (laminated veneer lumber, laminated veneer wood). Hybrid methods are also increasingly used in construction, combining wood with traditional materials (e.g. prefabricated concrete elements or steel).

The growing popularity of wooden houses is due to the numerous advantages of such structures. The most important include: good insulating properties (which reduces the energy demand during the building's life cycle) and acoustic properties, short construction time (especially in the case of modular houses, which can be assembled on the construction site in a few days), ease of reconstruction and modernization, lightness of the structure. An important factor is also the eco-friendliness of construction, because wood is a natural raw material with minimal emissions and has the ability to accumulate carbon dioxide. Wood-based construction, compared to traditional technologies based on steel and concrete (the production of which is very energy-intensive and highly emission-intensive), is characterized by lower CO_2 emissions. The carbon footprint throughout the life cycle of a wooden building is 25% smaller than that of a brick building, and taking into account the stage of production of construction products used to construct the building, the carbon footprint of a wooden building is over 80% smaller than that of a brick building (Płaziak 2013, Węglarz et al. 2019).

Wooden structures are increasingly used to construct public buildings, e.g. nurseries, kindergartens (the first investments of this type were already built in Poland), and clinics. The short construction time, as well as the ease of reconstruction of such buildings, especially structures based on simple, prefabricated modules, is important from the point of view of ensuring the flexibility of public infrastructure for residents - the function of the building can be changed in a relatively short time, adapting it to the current needs of local communities. Some countries take steps to promote wooden construction, both at national and local levels. In 2020 France already ordered that new public buildings be made of at least 50% wood or other materials of natural origin. From 2025, at least 20% of new residential buildings in Amsterdam are to be made of wood (i.e. contain at least 80% natural materials in detached houses, 65% in buildings up to 10 storeys and 50% in taller buildings). Switzerland has also taken a similar direction - increasing the use of wood in construction is one of the priorities of the national strategy "Wood Resource Policy 2030" (FAO 2020).

Wood is used to build increasingly taller buildings. Currently, the tallest building with a wooden load-bearing structure is located in Brumunddal, Norway (Mjøstårnet, 85.4 m), slightly lower, made of 75% wood, is located in Vienna (HoHo Wien, 84 m). The Australian city of Perth also has plans to implement a record-breaking 183-meter tower project called C6. Multi-story wooden buildings are also found in Canada, which in 2013 adopted an initiative promoting an increase in the share of wood in tall buildings ("Tall Wood Building Demonstration Initiative"), the USA, Germany, Sweden and the UK.

2. WOODEN CONSTRUCTION IN POLAND

In Poland, wooden buildings still constitute a small part of residential construction. In Poland, the ecological awareness of society is growing, and with it the demand for sustainable and environmentally friendly construction. The results of a study commissioned by the Forest Stewardship Council (FSC) confirm that as many as 76% of respondents believe that modern construction should use certified wood. This is an important signal that Poles see wood not only as a building material, but also as a key element in the fight against climate change. For over half of respondents (56%), wood is becoming the future of construction, and the industry should actively look for alternatives to traditional materials such as concrete or steel. The study showed that Poles expect construction to be more environmentally sustainable. Almost 6 out of 10 respondents (57%) indicate the need to use renewable energy sources, and a similar percentage (56%) suggest intelligent solutions to reduce utility consumption. Moreover, 46% of respondents believe that the location of the building should respect the natural environment, and 44% pay attention to technologies using recycled materials (FSC 2023).

The popularity of wooden houses, especially those with prefabricated modular structures, increased significantly at the beginning of the COVID-19 pandemic. Significantly reduced mobility and limited prospects for holiday trips have turned consumer interest towards plots of land, both recreational and those intended for year-round buildings. There has been increased interest in the so-called houses without a permit, but until the end of 2021, the simplified construction procedure covered houses with a building area of up to 35 m2, and from January 2021, as a result of changes introduced in the Polish Order program, the building area of a house may reach 70 m2. According to data from the General Office of Construction Supervision (GUNB), in the first 5 months of the new regulations being in force, 304 reports about such houses were registered (Sosna 2023).

From 2021, there is a double-digit increase in the prices of wooden products. Inflation in January 2021 was only 3.3% y/y, and six months later, in July, it reached over 15%. The prices of modular wooden houses have also increased. In July 2021, the price of a basic house with an area of 35 m2 in the price list of one of the leading Polish manufacturers was over 50% higher than in October 2020, and in the price list from May 2022, prices were nearly 85% higher than at the end of 2020. According to data from the Central Statistical Office, 1,160 wooden residential buildings were put into use in 2021, which constituted only 1.1% of all new residential buildings put into use in Poland (97.3% of which are single-family buildings). And although this share is growing year by year (in 2019, the percentage of buildings with wooden structures reached 0.8%), we are still talking about a small part of the residential construction market. However, taking into account the annual dynamics of changes in the number of buildings put into use, wooden buildings are characterized by much higher growth dynamics than buildings constructed using traditional technologies, 28.2% more buildings were put into use in 2021 than in 2020.

The actual number of wooden buildings constructed in Poland is much higher - according to estimates by experts from the Wooden House Association, even 5-6% of single-family construction is carried out using wood-based technologies, as indicated by data showing the activity of companies building houses in wooden structures. It is estimated that approximately 580 companies building using wooden technology are actively operating in Poland (including approximately 30-40 producers of modular houses) and approximately 260 companies building log houses. A year 2021 brought a significant increase in the number of agreements for financing single-family wooden houses - the number of loans in the PKO Bank Polski Group for such buildings increased by 80%, which significantly exceeded the increase for the entire segment of single-family houses. The broader segment of wooden and mixed-frame houses achieved even higher growth: +116%. (Balkiewicz – Żerek 2022).

3. TECHNOLOGIES USED IN POLISH WOODEN CONSTRUCTION

Today, the development of technology allows us to make wood a durable and safe raw material that can successfully replace materials such as concrete and steel. Architects, designers and investors can choose from a wide range of products with excellent properties. These include (IAP, 2024):

- **KVH** – construction wood, i.e. solid wood joined using micro-joints, which allows for obtaining beams of various lengths. KVH is resistant to deformation and the effects of stress, so it is suitable for, among others, wooden house structures, roof structures, terraces and small garden architecture.
- **CLT** – cross-laminated timber, i.e. multi-layer panels made of structural timber (KVH). Thanks to the cross-layer arrangement, dimensional stability, durability and appropriate stiffness of the board are achieved. CLT is used to build both multi-story residential buildings and smaller houses and commercial buildings.
- **BSH** – glued laminated construction timber. Thanks to this technology, individual elements can achieve impressive dimensions. First, the individual lamellas are joined lengthwise and then glued one to the other. This means that BSH is mainly used in the construction of larger facilities (sports halls, swimming pools), although it can also be used in single-family construction.
- **LVL** – layer-glued veneer. It most often comes in the form of construction boards. The veneer sheets are glued in layers in thickness and joined in length using lap joints. LVL is a material characterized by high durability and versatile use - in single-family, multi-family and industrial construction.
- **LSL** – laminated chip products, available in the form of beams or panels. Due to the interesting surface obtained thanks to the chips, they can also be a decorative element.

The use of modern processing methods makes wood gain new properties and thus becomes a valuable material for specialists in the architectural and construction industries. The raw material prepared in this way is durable, fire-resistant, friendly to the environment and residents, helps reduce the carbon footprint, ensures a healthy indoor climate and adequate insulation. Such wood also allows construction work to be accelerated and is more transport-friendly compared to reinforced concrete elements, the delivery of which to the construction site is usually associated with a rather complicated process.

Construction wood is used to build multi-story wooden buildings, including: CLT boards, often combined with prefabricated concrete or steel elements (hybrid technology). The production of CLT wood was initiated in the 1990s by the Austrian company KLH Massivholz. Currently, 5 countries are responsible for approximately 80% of the world's global supply of this raw material: Austria, the Czech Republic, Germany, Italy and Switzerland. Work on the development of CLT production technology in Poland was announced by Polskie Domy Drewniane (PDD S.A.), which received a grant from the National Center for Research and Development for the development of a technology for the production of construction panels made of cross-laminated pine wood from Poland, with an increased reaction to fire class, for the needs of multi-story construction. wooden. Polish developers are showing increased activity in the area of wooden construction. Erbud is expanding the production of modular non-residential buildings for the needs of German customers, and Unihouse is focusing on the segment of multi-family houses on the Scandinavian markets.

Polish construction companies have set themselves the goal of introducing innovative building materials based on natural and renewable raw materials to the market, which is why they are interested in glued structural wood material. Experts from the Research and Development Office are focusing on the development of Polish cross-laminated timber - CLT (cross laminated timber), which will allow the construction of multi-story ecological wooden buildings in the future. Wooden CLT elements are highly resistant to static loads, so they can be used as durable building elements - wall, ceiling or roof. Thanks to the cross-shaped structure of glued strips, this material is extremely resistant to expansion and contraction.

After the undisputed success of laminated timber, which began with the DRP patent No. 197773 of 1906, from around 1990, intensive development of a new product began in Europe - cross-laminated timber (known in the world mainly as CLT - Cross Laminated Timber, less often as X- LAM). CLT is an abbreviation for Cross Laminated Timber. These are spruce strips placed one on top of the other perpendicularly to each other and connected using adhesives using high pressure (6 kg/cm^2).

CLT boards have a multi-layer structure, entirely made of solid wood (Fig. 1). CLT is actually one piece of wood, with a small content (only 0.6%) of eco-friendly glue. The finished element is able to withstand heavy loads in many directions, is fireproof, and has excellent thermal and acoustic properties. It regulates the air humidity inside the building, creating a comfortable and balanced climate both in summer and winter. CLT makes design and construction easier. This is guaranteed by specific structural, physical and mechanical properties. Many designers consider this to be one of the greatest advantages of CLT construction. CLT boards enable the creation of a solid and fully wooden structure. They are characterized primarily by high durability and load-bearing capacity. CLT boards also have high fire resistance. Importantly, they burn only on the surface, thus weakening the structure much slower than traditional materials used in construction. In case of damage, individual wooden elements can be replaced without compromising the entire structure (BestTimberPolska 2023).

The value of sold production of Polish producers of prefabricated wooden buildings is estimated at approximately PLN 600-700 million in 2021 (estimate for companies employing more than 9 people). However, there are many smaller companies in the industry whose production is not included in production statistics.

4. CONCLUSIONS

The most frequently emerging determinant of the construction of the future in Poland will be issues related to eco-construction. This motto covers many issues, but the most common are: increasing the energy efficiency of buildings, searching for new building materials, using alternative energy sources. It is also worth noting that there have been voices stating that activities in this area will have to go beyond the certification of facilities. Ecological construction of the future is intended to reduce the amount of construction waste and minimize energy consumption related to the production and transport of building materials.

The key limitation to the development of wooden construction in Poland is still low public awareness of the advantages of such structures.

REFERENCES

1. Balkiewicz-Żerek, A. (2022): *Monitoring Branżowy Analizy Sektorowe. Więcej drewna w budownictwie?* Centrum Analiz PKO BP. Departament Analiz Ekonomicznych www.pkobp.pl/centrum-analiz
2. BestTimberPolska (2023): https://besttimberpolska.pl/portfolio-item/plyty-clt/
3. FAO (2020): *Status of public policies encouraging wood use in construction – an overview*.
4. FSC Polska, Badanie omnibusowe zostało przeprowadzone w Polsce w listopadzie 2023 roku przez SW Research na zlecenie Forest Stewardship Council (FSC) i objęło reprezentatywną grupę 1003 respondentów.
5. Izba Architektów Polskich (IAP), (2024): *Drewno certyfikowane – przyszłość budownictwa*.
6. https://www.izbaarchitektow.pl/pokaz/drewno_certyfikowane_%E2%80%93_przyszlosc_budownictwa,2684/#_ftn2
7. Płaziak, M. (2013): *Technologia tanich domów energooszczędnych jako odpowiedź na kryzys w budownictwie mieszkaniowym Technology of constructing cheap, energy-efficient house as an answer to the housing industry crisis*. Przedsiębiorczość – Edukacja. No 9. 214 – 226.
8. Potkány, M., Gejdoš, M., Debnár, M. (2018): *Sustainable Innovation Approach for Wood Quality Evaluation in Green Business*. Sustainability 10. No 9:2984.
9. https://doi.org/10.3390/su10092984
10. Ptaszyński, J. (2023): *Dekarbonizacja budownictwa*. Analiza Centrum AMRON
11. Raport ONZ: *Building Materials And The Climate: Constructing A New Future*. 2022.
12. Sosna, B. (2023): *Wartość rynku konstrukcji drewnianych w Polsce to już ponad 3 mld zł*. Inżynier Budownictwa.
13. United Nations Environment Programme (2022). *2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector*. Nairobi. ISBN No: 978-92-807-3984-8
14. Węglarz, A., Pierzchalski, M., Koc, D., Krysik, P., Pełczyński, J., Al Sabouni-Zawadzka, A., Wierzchołowska-Dziedzic, A., Skrzypek, A., Ogrodniczuk, J. (2019): *Środowiskowe aspekty nowoczesnego budownictwa drewnianego.* Krajowa Agencja Poszanowania Energii S.A. Warszawa

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WOODEN STRUCTURES IN SLOVAKIA: NAVIGATING MYTHS AND REALITIES - INSIGHTS FROM A 2020 MARKET SURVEY

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Abstract: This study explores prevalent myths about wooden constructions, covering concerns from durability to environmental impact. A market survey conducted in Slovakia in 2020, with over 400 respondents, emphasizes the persistent nature of these myths in the public mindset. The findings underscore the imperative to actively address and dispel these misconceptions.
Keywords: wooden houses; myths about wood; environmental consumer and citizen

1. INTRODUCTION

The common myths about using wood in constructions include the ideas that it's bad for the environment, less safe and durable than steel or brick, and more likely to catch fire. In this paper, we describe the most widespread myths and prejudices among the general public when it comes to construction. “Wooden building burns quickly” – People often worry that wooden buildings will burn quickly. However, wood needs to reach 350 degrees to burn, and factors like density and moisture affect how fast it burns (Hajek, 1997). When wood burns, it forms a charred layer that slows the process (Beranek, 2023). In contrast, concrete or steel structures can collapse in a fire, losing their strength. So, wooden buildings actually withstand fire better, making them a good choice for housing (Růžička, 2006). “The lifespan of wooden buildings is small” – The key to a wooden building's longevity lies in the quality of the wood used, with proper treatment and maintenance. Quality wood, treated to resist decay and fungal growth, can extend a structure's lifespan to 100-150 years (Kolb, 2011; Houdek & Koudelka, 2004; Růžička, 2006). Expert consensus confirms that timber buildings, when well-maintained, rival the durability of structures made from other materials like brick or concrete. Historical examples, such as Japan's Horyu-ji temple showcase wooden buildings enduring for centuries (Beranek, 2023). “The wooden building has low resistance to fungi, mould and wood-destroying insects” – Wooden buildings are only susceptible to biological damage when not properly chemically treated. To ensure longevity and resilience, it's crucial to treat the wood to prevent pests and maintain proper interior humidity through regular ventilation. By following these principles, wooden structures gain high resistance to pests, leading to their longevity (Houdek & Koudelka, 2004). “The wooden building has insufficient acoustic properties” – In the past, small residential cabins often had simple timber ceilings, leading to poor acoustics (Hájek, 1997). Today, timber constructions use composite timber-concrete floors for better stiffness and load-bearing capacity, along with improved fire resistance and sound insulation (Kuklík, 2005). There's a misconception about inferior indoor comfort in wooden buildings, but modern constructions don't face the cracking and noise issues of old wooden houses. They can achieve up to 15 decibels of sound attenuation compared to acoustic bricks of the same thickness (Nemrava in Beránek, 2023). “The wooden building has low thermal insulation properties” – Log cabins often struggle with thermal insulation due to their tendency to absorb and release moisture, along with potential air infiltration issues from poor sealing (Houdek & Koudelka, 2004). Modern wooden construction systems have addressed these challenges by incorporating insulation material within the walls, significantly improving thermal insulation in buildings (Štefko et al., 2014). "The wooden building has low resistance to natural disasters" – Wooden structures, known for their strength, weight, stiffness, and flexibility, fare better against natural disasters like earthquakes, floods, or tornadoes compared to other materials. Proper design and foundation construction are crucial for resilience (Růžička, 2006). Additionally, lightweight wooden construction offers high flood resistance. Quick replacement of wet cladding and insulation materials ensures long-term durability (Štefko et al., 2014). "Timber construction is expensive to build" – Wood remains the cheapest building material, with costs varying based on factors like size, quality, and construction time. Prefabrication in timber houses leads to significant savings, with construction often completed in a day on-site. Comparisons with multi-story wooden buildings vary, but recent research suggests costs are similar for large contracts over €10 million (Štefko et al., 2014). „Environmental myth – wood use causes deforestation " – In addressing concerns about deforestation, responsible forest management varies by country. Europe maintains stable forest regeneration, with only 62% of annual wood mass increment harvested (Beránek, 2023).

Currently in Slovakia, the trend of house and apartment construction based on silicate materials still prevails. Wood-based construction is slowly increasing its share in the Slovak market. The share of wooden buildings in new family housing delivered increased to more than 10% by 2022 (Zemaník, 2023). A significant change in favour of market development in Slovakia occurred after the revision of the norm STN 92 0201-2:2017 (Fire safety of buildings), which until 2017 allowed these buildings to be a maximum of two storeys high. Currently, it is possible to implement 5-storey wooden buildings (but with height restrictions), although wooden high-rise buildings with 10 or more storeys are being built abroad.

All stakeholders have a stake in the development of the market. It should be stressed that the supply side (companies) and the demand side (customers) have a role to play, but also government institutions with their support programme, professional associations, the academic platform, the third sector with its pro-environmental (timber as a raw material) and pro-social (work in the regions) initiatives, and the financial sector (access to money). Specific to the topic addressed here is the emphasis on consumer education and the dissemination of appropriate information. If we combine the availability of wood as a material (Slovakia is such a country) with a wider possibility to process it at home (to increase the added value by local work) with the aesthetic and environmental awareness of the market, we meet an environmental citizen - a person who is on the supply side (produces consciously) and is also on the demand side (a conscious/mindful consumer).The aim of our study was to find out which myths persist, or whether their refutation is noticeable and whether the awareness of the utility properties of timber buildings is improving (also in comparison with buildings made of materials substituting to wood).

2. METHODS

The following widespread myths about timber buildings were included in the survey: durability, fire resistance, resistance to biotic influences. The authors added additional statements on the topic of attitudes towards wood-based houses (the difficulty of construction in terms of finances, operation and maintenance; the environmental suitability of wood buildings; the trend of development of this market). Prior to the survey, the questionnaire was piloted on a sample of 25 respondents from Slovakia. The survey was conducted electronically using a questionnaire via google forms. The questionnaire included 3 demographic questions and 13 factual questions that related to myths and prejudices about wood construction. Data was collected during February in 2020 Slovak Republic via social media, mainly in groups related to construction, housing, etc. The collected questionnaires were purged of incomplete questionnaires and 410 well-completed questionnaires were used in the analysis. The non-probality sampling method was used – snowball sampling technique. We subjected the cleaned data obtained from the survey to univariate and bivariate analysis. In bivariate analysis of the data collected, we looked for relationships between the demographic characteristics of the respondents and their responses to the selected questions. The Pearson chi-square test of independence was used to examine the relationship between the variables, and Cramer's V and Pearson's contingency coefficient were used to examine the strength of the relationship between the variables. When analyzing the data in the contingency tables, we observed that the following condition was met: all the expected frequencies in the contingency table must be $E_{ij}>1$ and at least 80% of $E_{ij}>5$ at the same time. Statistical dependence was observed at the significance level $p<0.05$.

3. RESULTS

The sample of respondents consisted of 410 people of which more than 73% were women and almost 27% were men. Almost 31% of the respondents had completed university education, more than 52% had completed secondary education (high school) with diploma, while 15% of the respondents had completed secondary education without diploma and less than 2% had completed primary education. The 18 to 24-year-old category accounted for 21% of respondents. The most represented age category was 25 to 35 years (28.5%). In the 36 to 45-year-old category was 25% of respondents and in the 46 to 55-year-old category was 17% of respondents. Those older than 56 years were almost 8.5% of all respondents.

More than 73% of respondents think that wood-frame buildings will be popular in the future, and the same percentage of respondents think that the monthly cost of living in a wood-frame building is lower compared to living in a masonry building. More than 68% of respondents perceive wood construction as a more environmentally preferable building option compared to buildings made of silicate materials. Almost 63% of respondents perceive timber frame construction to be less demanding and cheaper compared to a brick house. Up to 48% of respondents thought that a timber house would burn down faster than a brick house, while 26% of respondents did not know the answer to this question. More than 60% of respondents thought that a timber building would outlast its 50-year lifetime, but almost 24% could not comment on this statement. A higher proportion of respondents (over 23%) who were unable to comment were also unsure about the claim that the timber structure has low resistance to biotic influences (mould, fungi, pests). At the same time, almost 32% of respondents stated that wooden buildings have low resistance to these influences. The ease of maintenance and care of timber buildings is perceived by 48% of respondents. Conversely, almost 38% stated that timber construction is difficult to maintain and care for.

Table 1. Proportion of responses

Statement	YES (%)	NO (%)	I DO NOT KNOW (%)
Do you think that wood construction is environmentally preferable to buildings made of silicate materials?	68.29	14.15	17.56
Do you think that the construction of a wooden house is more difficult and expensive compared to a brick house?	23.17	62.93	13.90
Do you think that timber construction will outlast a 50 year life span?	60.49	15.85	23.66
It is said that a timber frame house will burn down faster in a fire compared to a brick house, do you think this is true?	48.05	26.10	25.85
Do you think timber construction has low resistance to mould, fungi and pests?	31.22	45.37	23.41
Do you think that timber construction is difficult to maintain and care for?	37.32	48.05	14.63
Do you think that the monthly housing costs are higher for a timber frame building than for a brick building?	9.27	73.41	17.32
Do you think that in the future timber buildings will become more and more popular?	73.41	9.51	17.07

A statistically significant association between the variables studied was confirmed in seven cases. The strength of the dependence in these seven cases based on the Contingency coefficient and Cramer's V is weak i.e. the variables under study are weakly related but the dependence is confirmed. There was a statistically significant difference in the responses of men and women (gender) on the question of whether timber construction is environmentally preferable to buildings made of silicate materials. Almost 74% of women agree and less than 10% of women disagree with this statement. This contrasts with the responses of men, of whom almost 27% disagreed, while almost 20% of the men surveyed were neutral. A statistically significant correlation was also confirmed between age category and this statement. Almost 83% of the respondents in the age category of over 56 years took an agreeing position. Respondents in the 25 to 35-year-old category expressed the lowest level of agreement, with just over 60% agreeing with this statement, and also had the highest level of disagreement with this statement (23%). The highest proportion of 'don't know' responses was in the 46 to 55-year-old category. A statistically significant relationship was confirmed between the gender of the respondent and the statement that a timber-framed house will burn faster in a fire compared to a masonry house. Approximately 30% of women could not comment on the statement, but up to 46% agree. That is to say, they consider a wooden building less safe in terms of fire safety compared to other buildings. Up to 54% of men also think that a wooden house is more flammable and burns more quickly compared to a brick house, but almost 33% of men disagree with this statement. In response to the question 'Do you think that building a timber-framed house is more difficult and more expensive compared to a brick house?' there were statistically significant differences between the age categories of respondents. The highest number of affirmative responses (35%) were in the 18 to 24 age category and the lowest (almost 12%) were in the over 56 age category, while almost 72% of them do not consider the construction of a timber-frame house to be more difficult and expensive. This attitude is also held by 44% in the 46 to 55-year-old category, but interestingly, almost 1/3 of the respondents in this age category were unable to express their opinion. A statistically significant relationship was confirmed between age category and responses to the question of whether a timber building would outlive its 50-year lifetime. More than 1/4 of the respondents in the 25 to 35 age category disagreed. Up to 40% of the 'don't know' responses are from respondents in the 46 to 55 age category, but they also expressed the lowest level of disagreement (7% of them). There is also a statistically significant dependence on the age category of the responses to the statement that a wooden house will burn faster in a fire compared to a brick house. Up to 67% of respondents aged 18 to 24 agree with this. The highest level of disagreement (34%) was expressed by the 36 to 45 age group. As many as 40% of the 46 to 55 age group were unable to comment. A statistically significant relationship was shown for age category and responses to the statement: 'Do you think the monthly housing costs are higher for a wooden building than for a brick building?' Only 9% of all respondents agreed with this statement and almost 74% of respondents disagreed. The highest percentage of disagreement (almost 86%) was expressed by the 56+ age group, similarly 36-45-year-old respondents expressed up to over 80% disagreement. The 18 to 24-year-old category had the highest number of agree responses at almost 18%. Almost 32% of the respondents in the age category of 46 to 55 year olds could not take a stand on the statement.

4. DISCUSSION AND CONCLUSIONS

In addition to the relatively consistently high proportion of the public with attitudes unfavourable to greater development of the market for timber buildings, we also see from the results a high proportion of respondents who were unable to comment on the statements. A high proportion of "don't know" statements (between 23 and 26%) refer to myths about the persistence of fire hazards in timber buildings and the low resistance of timber buildings to biotic influences. Overall, there is a high percentage of such responses for the statements in Table 1 (at least 13% of respondents for each statement). This could be explained by the consideration that wood buildings (and buildings in general) are long-term/durable consumer products, they are also investment products, and due to the breadth and depth of purchasing decisions, this is a complex process. This type of product is not evaluated and considered as often by the average consumer (our respondent) as is the case with consumer products. When buying (house building), it is a predominantly rational buying behaviour with elements of an emotional nature, characterised by the fact that customers first and foremost seek and study a large amount of information about the product. Only after a rational consideration of a complex set of factors do they make a purchasing decision. That is, if we only asked respondents who were seriously considering buying/building a house and had gone through the decision-making process, we would expect a lower proportion of "don't know" responses.

The myths we included in the survey are common and widespread in the Slovak population. If consumers expand their knowledge, seek or receive information about products in this market, attitudes may change, and myths may be suppressed. The choice of housing (type of construction, construction material) is influenced not only by taste but also by personal experience - e.g. where a person has lived, worked, spent some time occasionally (holiday, business trip, visit). Sproles (1974) observed that fashion phenomena play a significant role in influencing consumer decisions for various products, including furniture, home furnishings, and architectural designs for housing. Podner (2013) further concluded that furniture manufacturers and retailers not only sell products but also provide opportunities for consumers to spend quality time comfortably with family and friends in their homes.

Consumer education is a process that should not lead to higher consumption of 'environmentally friendly products' (and achieve the so-called rebound effect), but to mindful consumption. To lead to preferences based on pro-social (dignified work in the regions) and pro-environmental values and attitudes. It is a preference (to an appropriate extent) for materials substitutable to those that burden the environment in the process of production, consumption and, ultimately, waste. Substitutes are often products that are conceptually encompassed by the bioeconomy as part of an economy that uses renewable biological resources. Therefore, we see the environmental citizen not only on the demand side, but also on the supply side. It is a 'agent of change', a carrier of the new economic paradigm of transition from a linear to a circular economy. With its attitude and behaviour, it inspires, for example, a wider use of wood as a material, both in its traditional and new applications.

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REFERENCES

1. Beránek, M. (2023). *The 5 Most Common Myths Around Wooden Buildings*. *Perspektiv*. Retrieved from [https://perspektiv.cz/en/research/the-5-most-common-myths-around-wooden-buildings/]
2. Hájek,V. (1997). *Stavíme ze dřeva.* Praha: Sobotáles, 1997. 153 s. ISBN 80-85920-44-1.
3. Houdek, D., Koudelka, O. (2004). *Srubové domy z kulatin.* Brno: ERA, 2004. 161 s. ISBN 80-86517-97-7.
4. Kolb, J. (2011). *Dřevostavby*. Praha: Grada, 2011. 320 s. ISBN 978-80-247-4071-3.
5. Kuklík, P. (2005). *Dřevené konstrukce*. Praha: ČKAIT, 2005. 172 s. ISBN 80-86769-72-0.
6. Ponder, N. (2013). *Consumer attitudes and buying behavior for home furniture*. Reportprepared for the Furniture Outreach Program at Franklin Furniture Institute, Starkville,Mississippi, USA.
7. Růžička, M. (2006) *Stavíme dům ze dřeva*. Praha: Grada, 2006. 120 s. ISBN 80-247-1461-2.
8. Sproles, G. B. (1974). ”*Fashion Theory: a Conceptual Framework*”, in NA - Advances inConsumer Research Volume 01, eds. Scott Ward and Peter Wright, Ann Abor, MI : Associationfor Consumer Research, pp.: 463-472
9. Štefko, J a kolektív. (2014). *Všetko o bývaní: Moderné drevostavby*. 1 (1), 16-17 s. ISSN 1335-09
10. Zemaník, P. (2023). DREVOSTAVBA ROKA 2022: rekordný počet nominácií. Available at: https://drevmag.com/2023/03/22/drevostavba-roka-2022-rekordny-pocet-nominacii/

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THE USE OF ENGINEERED WOOD PRODUCTS IN SUSTAINABLE BUILDING CONSTRUCTION IN MACEDONIA

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Abstract: Wood, abundantly available locally since ancient times, played a pivotal role in Macedonian architecture. Functioning as a structural and decorative material, it enhanced both the exterior and the interior aesthetics of buildings. Despite its wide usage in the past, wood is nowadays mostly used in the mountain regions of Macedonia for holiday cottage, in the interior as furniture, flooring, ceiling and mouldings, and in exterior mostly as façade decoration due to its appealing aesthetics, and less, for walk paths. A new wave of companies specialising in the production of single-family timber houses is emerging. Over the past two decades, a novel category of structural wood products has evolved, laying the foundation for a diverse range of increasingly functional building solutions, unifying performance and sustainability aspects. The evolution was enabled by innovative industrial processes that offer larger dimensions and superior engineering properties for structural products. The outcome is a class of products commonly known as engineered wood products (EWPs), which are gaining momentum in architectural design and building applications. Macedonia is actively aligning with the trends observed in more developed countries, integrating the application of EWPs in its construction processes. Although challenging, undertaking this process is worthwhile, especially if we aspire to align with sustainable trends.
Keywords: engineered wood products, application, architecture, Macedonia

1. INTRODUCTION

In Macedonian architectural history, wood has held a high position, serving as a construction material, for both structural and non-structural elements. The availability and ease of use have made the wood indispensable since ancient times, which lead to its organic integration in Macedonian vernacular architecture. Wood was used in diverse applications, serving as a material for the structure of the building, and for architectural elements such as stairs, doors and window frames. Choosing wood for buildings stemmed from its inherent qualities, fostering a connection between residents and their natural surroundings. The choice for including the wood into homes stemmed from its innate qualities, fostering a connection between the users and their natural surroundings. Traditional Macedonian dwellings combined high technical standards with comfortable living, providing a holistic residential experience. Architectural designs were contextually linked, reflecting the region's unique geographical and cultural features, leaving a profound imprint (Figure 1).

Despite its significant historical usage, modern-day Macedonia predominantly employs wood in mountainous regions small houses, in the interior design or as a decorative element on the façades because of the beautiful aesthetic appeal. In recent decades, material choices in Macedonia have become increasingly limited, with designers, investors and companies sticking to non-wood materials. The widespread use of steel and concrete, particularly following the 1963 earthquake in Skopje, has diminished the importance of wood.

Figure 1. The Ottoman Era Houses in Ohrid, Macedonia – the wooden structural system (bondruk system) of the traditional Macedonian house

After the earthquake, numerous nations provided assistance to Skopje for its reconstruction, resulting in the introduction of diverse building materials for the new structures. To address the housing needs of those left homeless by the earthquake, a new system of timber prefabricated houses, known as Swedish or Finish prefabs, was adopted. This kind of houses were built on a several locations in Skopje and were ideal solution for fast construction with light flexible materials, suitable for seismically active regions.

Nowadays, progressive construction practices across Europe, including Macedonia, are increasingly focused on environmentally friendly materials, particularly wood and various EWPs. However, the debut of novel products within the Macedonian construction industry often encounters limited awareness and heightened uncertainty among consumers.

Nonetheless, the situation is changing in the last few years, due to the impact of European trends, and wood application is increasing. People's awareness is slowly evolving, and they are beginning to see the positive features in living and using sustainable EWPs. The richness of the natural local renewable materials presents a strong base for the development of innovative approaches in the building sector using natural resources. The heightened incorporation of EWPs within modern Macedonian architecture stands as a significant facet in shaping a more environmentally sustainable future for the built environment. Consequently, there is a pressing need for greater dissemination of information concerning their application and public perceptions.

The limited adoption of EWPs in Macedonia can be attributed, in part, to the absence of cross-laminated timber (CLT) or glued-laminated timber (GLT) production facilities within the country. When a demand arises for these specific types of EWPs, they are typically sourced through import from neighbouring countries that possess established production capabilities. Commonly, CLT and GLT find application in the construction of roof structures in buildings. The absence of local production in Macedonia leads to elevated prices for these essential structural components, thereby causing discouragement among investors. Architects are endeavouring to persuade investors to incorporate these elements, yet the ultimate decision invariably rests with the investors, who care most about economic viability. Figure 2 shows a project for a Botanical Garden in Skopje with GLT application for the structure.

In Macedonia, the wood sector has a very long tradition and has always been an important segment of country economy. To get a better picture of the importance of the forest sector, some additional information regarding relevant forestry statistics is presented in Table 1. Table 2 identifies the key differences in wood-based construction in Macedonia.

Figure 2. Project for Botanical Garden in Skopje, designed by Faton Kalisi

Table 1. Macedonia – Selected Forestry Data, 2023

Population*	2 093 599
Total area (km^2)**	25 713
Surface area of forested land (km^2)***	10 015
Forested area (%)***	39.71%
Number of naturally occurring tree species	319
Growing stock (m^3)	$75.94 \cdot 10^6$
Annual growth of growing stock (m^3 forest)	$1.62 \cdot 10^6$
Annual harvest (m^3 forest)	$1.34 \cdot 10^6$
Hardwoods (m^3)	-
Softwoods (m^3) **Sawn wood**	-
Consumption per capita (m^3/y)	0.1

* Worldometers. Available online: https://www.worldometers.info/world-population (Accessed on 24th of March 2024)
** Worldbank.org. 2020. Available online: https://www.worldbank.org/en/home (Accessed on 24th of March 2024)
*** World Data Atlas – North Macedonia – Forest Area – 2021. Available online: https://knoema.com/atlas/North-Macedonia/topics/Land-Use/Area/Forest-area (Accessed on 24th of March 2024)

*Table 2. Wood-based Construction in Macedonia**

Share of detached houses in residential construction (%)*	n.a
Market share of wood in detached houses (%)*	2–5
Market share of wood in multi-story construction (%)	-
Maximum number of floors allowed from wood, with sprinklers, in 2024	Not specified in the fire-fighting standards
Key wood construction techniques	Timber panel Traditional timber-frame Massive timber
Organizations promoting wood at national levels	Faculty of Civil Engineering Skopje, University "Ss. Cyril and Methodius"; Faculty of Engineering, International Balkan University, Skopje; Building companies such as Geo-Ing Wood Construction in Skopje, Eco House MK in Skopje, Hot-Hot Construction – Representative Office in Skopje, Tehcom from Kochani and Ken Panel from Skopje
Sawn timber consumption per capita (m^3/y)	0.1

*MKD: North Macedonia in numbers, 2022, Republic of North Macedonia, State Statistical Office, Skopje

2. THE STUDY

2.1. Objectives

The objective of this study was to better understand architects' perception of EWPs and identify factors that positively contribute to the likelihood EWPs usage/specification could increase in Macedonia. Based on these perceptions, we hope to identify communication mechanisms and messaging to increase architect understanding of EWPs. Changing specifier preferences regarding the positive attributes of EWPs may greatly affect the market structures for wood products that, in turn, impact demand, supply, opportunities for manufacturers, increasing employment, and overall local, regional, and national economic development.

2.2. Methods

A survey questionnaire was constructed and developed by an international group of architects as a part of a larger survey. The study methods included a two-stage survey; in the first stage, personal interviews were conducted and then, based on input from these in-person interviews, in the second stage an exploratory web-based survey was designed. The survey questionnaire was in English.

The target population of the survey included practicing architects' members of Chamber of Certified Architects and Certified Engineers of the Republic of Macedonia. Respondent data were collected through the on-line survey and the instrument was programmed in 1ka, (Version 21.05.25 [3]); random sampling of these association populations was used. Based upon similar studies [2] a response rate of 15–35% is considered adequate for analytical purposes for business/corporate surveys. Considering an expected response rate within this range and a sampling error of 10% we sent out 320 questionnaires. In Macedonia, the survey process took place from late May 2023 to mid-June 2023. Two survey reminders by e-mail followed the initial mailing. 91 responses were received. Taking into account non-deliverables (e.g. invalid e-mail addresses or out-of-business firms); the response rates was 28%.

The questionnaire was divided into four parts; the first part contained questions about general perceptions and familiarity of architects with EWPs. The second part covered questions regarding their specifications of non-load and load-bearing systems, followed by the third part with questions on information sources and information needs of architects. The last part included demographic questions about respondent gender, country, profession and experience. Only the initial segment, which consisted of inquiries regarding architects' overall impressions and level of familiarity with EWPs, will be presented in this paper.

3. RESULTS AND DISCUSSION

From a list provided, including photos, respondents were asked to identify which EWPs they were most familiar with; the possible selection products are listed in Table 3. The cells reflecting a percentage higher than 80% are coloured grey. In general, the overall familiarity with EWPs is relatively high.

Table 3. Respondent familiarity with EWPs

Answers	**GLT** Glued laminated timber 	**CLT** Cross-laminated timber 	**PSL** Parallel strand lumber 	**LSL** Laminated strand lumber 	**SWP** Solid wood panel 	**LVL** Laminated veneer lumber 	**PW** Plywood 	**LDF/MDF** Low/medium/ high-density fibreboard 	**VP** Veneered particle board 	**PB** Particle -board 	**OSB** Oriented strand board 	**LS** Light sandwich panel 
No	6	18	25	37	6	23	7	13	17	18	3	40
	6.6%	19.8%	27.5%	40.7%	6.6%	25.3%	7.7%	14.3%	18.7%	19.8%	3.3%	44.0%
Yes	85	73	66	54	85	68	84	78	74	73	88	51
	93.4%	80.2%	72.5%	59.3%	93.4%	74.7%	92.3%	85.7%	81.3%	80.2%	96.7%	56.0%

The most common EWPs familiarity in Macedonia are structural GLT, SWP, PW, OSB – over 90% respondents from Macedonia note familiarity with these products. CLT, PB, and VP are also well known by respondents, less known are PSL, LVL and LSL. Respondents also selected the five most familiar EWPs. We used a method called the Modified Borda count, where the most familiar EWPs gets 5 points, the second most familiar 4 points… and the fifth most familiar, 1 point. The EWPs with the highest sum of points was placed first. As seen in Table 4, the first five ranked EWPs are coloured grey. In Macedonia OSB is ranked first, followed PW and GLT.

Table 4. Respondent familiarity with Top 5 Ranked EWPs

	GLT	CLT	PSL	LSL	SWP	LVL	PW	LDF/MDF /HDF	VP	PB	OSB	LS
Points	254	49,5	45,8	42,1	237,7	112,3	286,8	107,4	98,7	43,6	292,9	74,8
Ranks	3	11	12	14	4	5	2	6	8	13	1	10

Respondents were asked if they think there has been an increased use of new EWPs in the last 5 years. 35% think that the use has increased, while more than 50% think it remained the same.

Further on, respondents were asked to identify their clients' perceptions of EWPs. Their responses suggest that clients in Macedonia generally want to have more information about EWPs. Additionally, around 5% from Macedonia believe that their clients are not interested in EWPs.

The objective of this study was to better understand architects' perception of EWPs and identify factors that positively contribute to the likelihood EWPs usage/specification could increase in Macedonia. The information obtained in this study will contribute to an understanding of the probability of innovative bio-based building materials application with minimal environmental impact in residential and non-residential buildings, as well as high-rise buildings. Moreover, it will allow for a greater understanding of the drivers of and barriers to its increased use.

4. CONCLUSIONS

The overarching goal of this study was to identify architects` perceptions regarding potential advantages/benefits and disadvantages/challenges in specifying EWPs. There is a growing interest in engineered wood products (EWPs), particularly among young architects and students. This enthusiasm stems from a range of favourable attributes, with a significant emphasis on the visually appealing aesthetic. These individuals are aligning themselves with the principles of sustainable architecture and biophilic design, drawing inspiration from the inherent beauty of nature.

The emphasis on sustainability and the principles of a circular economy has instigated a paradigm shift in architectural and construction practices, directing attention towards a more responsible and ecologically conscious approach. Moreover, the appeal of wood and EWPs extends beyond its ecological merits. Their warm and inviting aesthetic, in harmony with the biophilic design principles that emphasize a connection to nature, resonates strongly with contemporary sensibilities. Therefore, the wood application is increasing in Macedonia (Figure 3).

Figure 3. The project "NOW", designed and constructed by a team led by Bekir Ademi, architect from Project Studio “BINA”, 17. Biennale Architettura 2021(left) and Summer Scene City Park Skopje built 2022 (right)

Based on the survey findings, it is evident that architects in Macedonia exhibit a favourable attitude towards EWPs, with a notably high level of familiarity with these materials. Moreover, there is a growing interest among architects in acquiring further information about EWPs, indicating a positive trend towards potential changes in the application of construction materials. This can be a solid foundation for disseminating information about EWPs through various educational channels such as the educational system, workshops, lectures, and training sessions. These platforms can effectively educate architects on the characteristics, applications, and utilization of EWPs, thus empowering them to make informed decisions and integrate these materials into their projects more effectively.

REFERENCES

1. Glavonjić, B., Kitek Kuzman, M.; Sandberg, D. (2022) *Engineered Wood Products- Wood as an engineering and architectural material.* Engineered wood products in contemporary architecture: new ways to use timber in future. Kompozitni proizvodi od drveta u savremenoj arhitekturi: novi načini korišćenja drveta u budućnosti. Luleå: Luleå University of Technology, p. 272.
2. Kitek Kuzman, M., Klarić, S., Barčić, A. P., Vlosky, R.P., Janakieska, M. M., Grošelj, P. (2018) *Architect perceptions of engineered wood products: An exploratory study of selected countries in Central and Southeast Europe*, Construction and Building Materials, Volume 179, p. 360-370. doi.org/10.1016/j.conbuildmat.2018.05.164.
3. 1KA (Version 21.05.25) Software. Ljubljana: Faculty of Social Sciences. 2023. Available online: https://www.1ka.si (accessed on 28 November 2023).

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INNOVATIVE APPROACH TO EXTERNAL ENVELOPE OF A TIMBERFRAME HOUSE

Pavol Sedlák, Dominika Búryová, Daniel Bebej, Róbert Uhrín, Patrik Štompf

Abstract: Climate change is one of the greatest environmental challenges, and social concern about it grows every year. Europe has been the most decisive in leading the global energy transition, supporting the achievement of a low-carbon economy through targets and regulatory policies. The European Green Deal initiative is also targeting its significant part - process of building and renovation in regard to their currently unsustainable methods.

The operations of buildings account for 30% of global final energy consumption and most of this energy is used for heating or cooling. Today, roughly 75% of the EU building stock is energy inefficient. Such energy loss can be minimised by improving existing buildings, mostly by building's external envelope enhancements of its insulation. The envelope has also impact to thermal comfort of occupants, and there could be conflicting demands for the comfort vs. heating energy, in terms of insulation level and shape of the building.

This paper provides insight into timberframe residential house with innovative external envelope providing exceptional level of thermal insulation, together with energy demand and thermal comfort assessment, by means of calculations and in-situ monitoring. As it is proved later, the comfort can be guaranteed even in extreme hot summer period in such a house without mechanical cooling, in contrary to widely accepted opinion of poor performance of lightweight buildings.

Keywords: timberframe house, thermal comfort, temperature monitoring, external envelope

1. INTRODUCTION

Timberframe houses provide excellent thermal comfort for users even with relatively thinner external envelope structure [4] when compared to traditional masonry structures. This is due to the use of highly efficient thermal insulation in all layers of the envelope – walls, ceiling and roof.

There are rumours about quality of the indoor environment in such houses due to low heat capacity of the wood structures, which is resulting into excessive internal temperature fluctuations, especially during summer. Also, it is found that prejudice regarding the deficiency of timber houses, in terms of fire resistance, durability and stability, persists in the minds of consumers [3], what can be usually explained by poor workmanship, material, design or technology.

2. ENERGY CONSUMPTION VS THERMAL COMFORT

To achieve significant heating energy reduction, compact shape of a building is one of the main aspects of the design. From this point of view, two-story buildings are ideal solution, as they can provide geometrical shape with exceptional envelope/volume ratio, often similar or close to a cube. On the other hand, single-story buildings show high portion of floor and ceiling, and the envelope/volume ratio is notably worse.

In terms of summer overheating risk, single-story houses provide better conditions, mostly due to concrete slab on ground, effective night cooling by horizontal natural cross-ventilation and easy shading by roof overhangs. In contrary, upper floors of multi-storey houses tend to accumulate the heat, lacking heat capacity of ground floor and during night ventilation the lower floors start to cool first, with warm air rising vertically to upper floors and not cooling them sufficiently.

However, there are number of other interconnected factors affecting the situation. The other important parameters are wall insulation, airtightness, ventilation type, windows U-value, Solar Heat-Gain Coefficient (SHGC) of windows [1] and many further.

3. CASE STUDY HOUSE

The analysis was performed on single-story detached house. The floorplan is square-shaped, roof overhangs and exterior blinds provide shading in summer.

There is central mechanical ventilation with heat recovery (MVHR) installed, space heating and domestic hot water systems (DHW) are supplied by heat pump and partially by a wood stove with low CO_2 emissions [7]. Heat is distributed by warm air in ventilation system, what can create certain issues with simultaneous stove operation, as discussed later – though the combination is simple if compared to other systems [2] available.

Figure 1. Parts of the house during construction process

Figure 2. Finished house.

4. EXTERNAL ENVELOPE DESCRIPTION

The building envelope meets passive house standard in terms of thermal insulation level - total thickness of insulation is 470mm in external wall, 550mm in ceiling and 200mm on ground floor concrete slab. Windows have reinforced plastic frame with U_f=0.94 $Wm^{-2}K^{-1}$ and triple insulating glass providing U_g = 0.6 $Wm^{-2}K^{-1}$

The external wall is formed by an innovative 360 mm composite box studs made of OSB and wood, there is layer of wet plastered external insulation installed from exterior. Additional layer of soft insulation with gypsum board to interior protects OSB as vapour barrier. An airtightness level was verified during the construction by Blower Door apparatus [6], to ensure low undesirable air infiltration through the envelope.

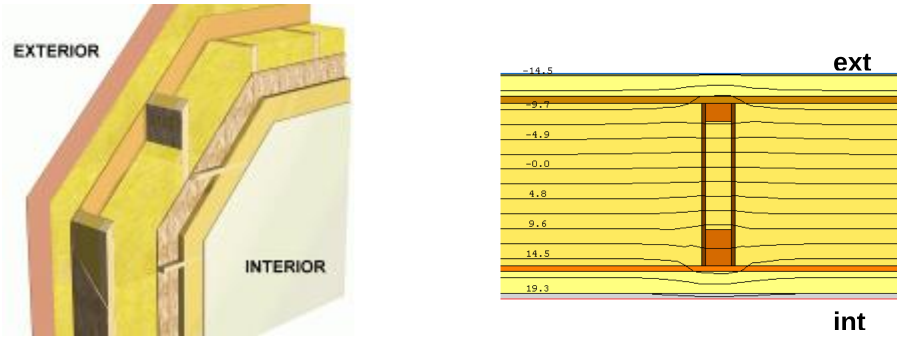

Figure 3. External wall composition and 2D thermal model with isotherms

Ceiling above the heated space is formed by the lower beams of roof trusses, with 490 mm layer of loose thermal insulation. Additional insulation of 60 mm fills gap between interior plasterboard and the vapor/airtight foil, thus protecting the barrier in similar way as in the external wall.

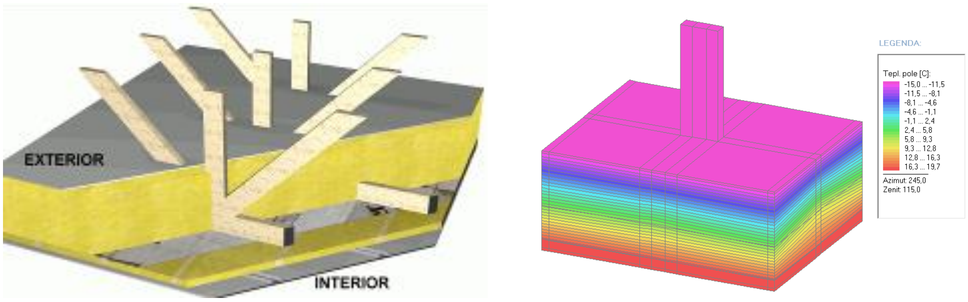

Figure 4. Ceiling composition and 3D thermal model with colour temperature distribution

While calculating U-values, repeated thermal bridges were taken into account, by 2D/3D modelling (Fig. 3, Fig. 4). The U-values of 0.073 $Wm^{-2}K^{-1}$ for ceiling and 0.084 $Wm^{-2}K^{-1}$ for the wall are far better than required or recommended by STN 73 0540 or by Passive House Institute.

5. THERMAL COMFORT - MONITORING

The monitoring took place in the house during an entire year, indoor climate and outdoor air parameters had been recorded to verify the quality of thermal comfort throughout the year. Temperature and relative humidity curves for different rooms during typical winter and summer week were selected for comparison.

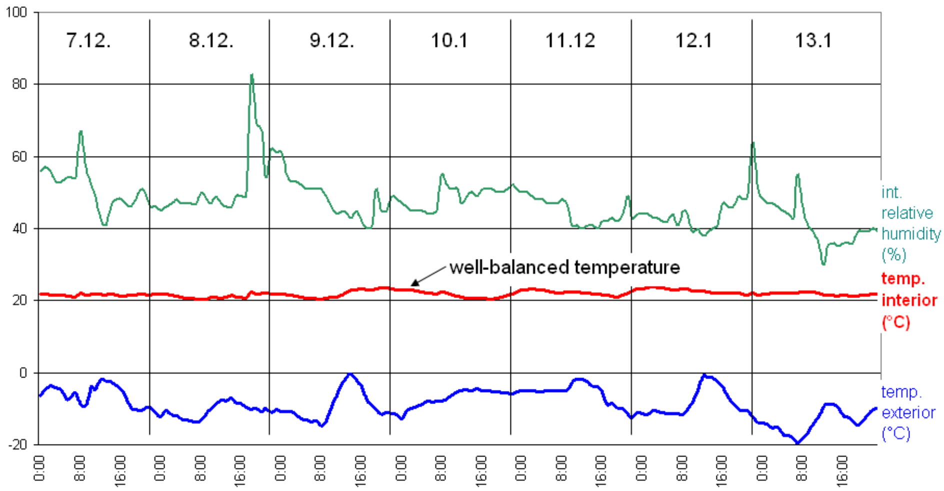

Figure 5. A winter week – internal and external temperatures, bathroom

When analysing the data, it was found that during winter period, at the time of the lowest drop in the outdoor temperature, the indoor air temperature was always above 20ºC, which ensures thermal comfort in the interior together with high surface temperatures resulting from low U-values (Fig. 5).

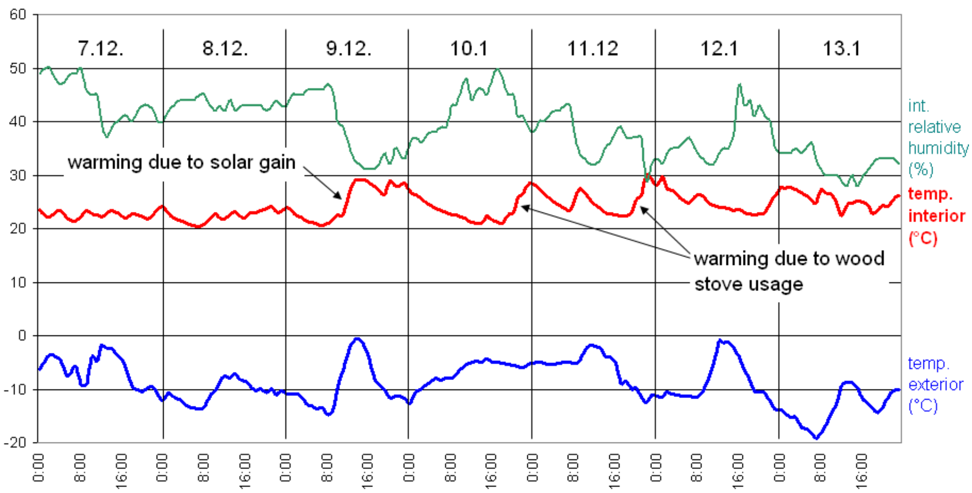

Figure 6. A winter week – internal and external temperatures, living room

It was interesting to find out that moderate overheating of the interior in winter is possible only due to solar radiation. Significant overheating occurred due to wood stove usage, when internal temperature almost reached 30 °C (Fig. 6). This can be attributed to the high power of the stove and inflexible heat distribution, when the hot-air system does not have the operational possibility to disconnect individual rooms from the main heat source in case of extraordinary heat gains.

Preliminary assessment of the summer overheating by Passive House Planning Package (PHPP) revealed that during typical usage, the temperature in interior rises above 22°C for approximately 2-3 days only – as the house benefited from exterior blinds installation on main south windows, MVHR system and exceptional level of the envelope insulation.

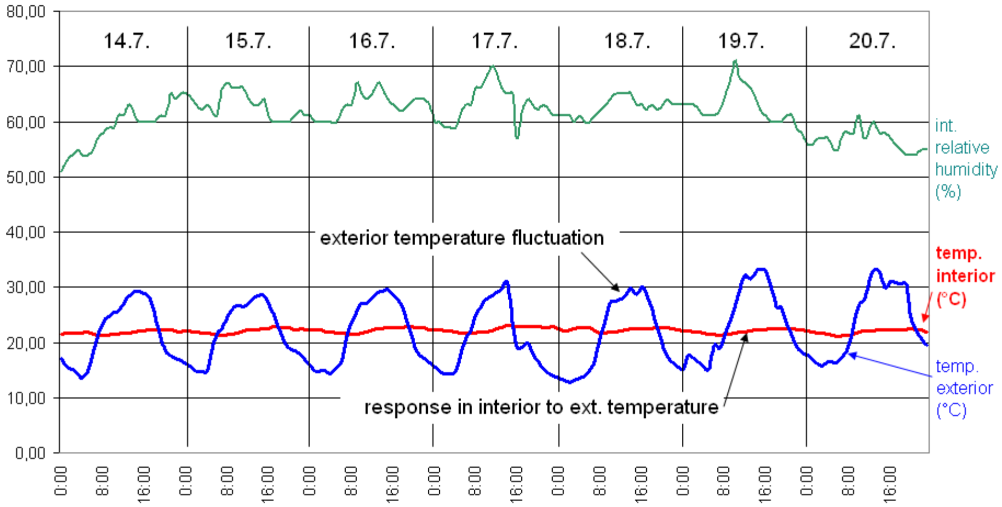

Figure 7. Hot summer week – internal and external temperatures, room

For most of the structures, steady hot summer period (Fig. 7) is crucial for the thermal comfort, as heat can accumulate over the time, and is considered worse than sudden extreme conditions usually followed by calming down or rain.

Recorded summer temperatures showed that the maximum interior temperature reached decent T_i=23.11 °C, even during hot summer day with local external temperature peak T_e=33.3°C, for the period (Fig. 7). The curve shape and maximal values generally confirmed PHPP calculation.

6. CONCLUSION

After comprehensive evaluation of the house, it can be confirmed that houses with a highly insulated building envelope have a positive effect on thermal comfort throughout the year and, in addition, maximally reduce the need for heating energy.

Paradoxically, a slight overheating of the interior during the winter period was demonstrated, because of the wood stove operation together with warm-air heating system used, which cannot react to local extreme heat sources and regulate the heat supply to individual rooms.

As a result, the testing showed that general prejudices about summer overheating of timberframe houses are misleading, and probably can be applicable only for old or substandard structures. A decisive indicator for all buildings, not only for wood-based buildings, is the existence of shading devices, high thermal resistance of walls and windows, heat recovery during ventilation and well-informed occupants.

And, in addition, when sustainability of wood [5] is considered, timber structures can be regarded eligible for the demanding future.

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REFERENCES

1. Baba, F. M., & Ge, H. (2020). *Overheating risk of a single-family detached house built at different ages under current and future climate in Canada*. In E3S Web of Conferences (Vol. 172, p. 02004). EDP Sciences.
2. Cablé, A., Georges, L., Peigné, P., Skreiberg, Ø., & Druette, L. (2019). *Evaluation of a new system combining wood-burning stove, flue gas heat exchanger and mechanical ventilation with heat recovery in highly-insulated houses*. Applied Thermal Engineering, 157, 113693.
3. Hu, Q., Dewancker, B., Zhang, T., & Wongbumru, T. (2016). *Consumer attitudes towards timber frame houses in China*. Procedia-Social and Behavioral Sciences, 216, 841-849.
4. Michálková, D., & Ďurica, P. (2022). *Experimental verification of thermal insulation in timber framed walls*. Materials, 15(6), 2040.
5. Remic, K., Sitar, M., & Jošt, M. (2023). *Analiza okoljskih in ekonomskih vplivov mineraliziranega lesa na primeru Plečnikove klopce z uporabo LCA in LCC metodologije*. Les/Wood, 72(2), 57-68.
6. Tombarević, E., Vušanović, I., & Šekularac, M. (2023). *The Impact of Windows Replacement on Airtightness and Energy Consumption of a Single Apartment in a Multi-Family Residential Building in Montenegro*: A Case Study. Energies, 16(5), 2208.
7. Trubetskaya, A., Lin, C., Ovadnevaite, J., Ceburnis, D., O'Dowd, C., Leahy, J. J., ... & Smith, W. (2021). *Study of emissions from domestic solid-fuel stove combustion in Ireland*. Energy & Fuels, 35(6), 4966-4978.

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END-TO-END GRAIN JOINTS IN THE CONSTRUCTION OF SOLID WOOD FURNITURE

Seid Hajdarevic, Ibrahim Busuladzic, Sandra Martinovic, Alen Ibrisevic, Murco Obucina

Abstract: This paper investigated the bending strength and modulus of elasticity in bending of four types of end-to-end grain joints in solid wood furniture. The joint elements were assembled with PVA-c glue with different positions of profile adhesive surfaces (tenon joint, dowel joint, and puzzle joint). The four-point bending test was used to obtain the maximum force and deflection of the beam specimens. The results were compared with the bending test results of the finger joint that is widely used in the solid wood furniture industry today. Although they are less commonly used for longitudinal assembly, and compared to finger joints, joints with a lap or tenon have lower bending strength, they can achieve the appropriate strength for furniture elements made of solid wood. Also, the results of the E modulus do not demonstrate a significant difference between all tested types of joints.

Keywords: wood, end-to-end grain joint, bending strength, modulus of elasticity, furniture

1. INTRODUCTION

In the wood construction process, one of the tasks is the selection of joints or connections according to the required assembly principle. The main problem with end-to-end grain joining is the strength reduction at the assembly point. Assembling wood elements only with glue on the front end does not result in the joint high strength, so it is not often used for wood lengthening. In common, the profile-adhesive joints are used. By increasing the contact surface of the joint, the bonding surface increases, which achieves a satisfactory strength of the joints, e.g. finger joints are widely used in the wood industry today (Barboutis and Vasileiou 2013). Although they are less commonly used for longitudinal assembly, furniture elements made of solid wood can also be obtained with lap or tenon joints.

The traditional and common joints have the ends to be connected in such a way that adhesive surfaces are primarily side grain. Today computational systems for designing wood structures and CNC machining facilitate the creation of custom joints. Properties determination of such joints is challenging because of the geometric complexity and unspecified joint behaviour (Larsson et al. 2020). Many types of end-to-end grain joints have been designed, analysed and evaluated and they were difficult to use, had poor strength, and did not prove to be effective (Khelifaa et al. 2015). The effect of numerous variables (wood properties, geometrical joint profile, adhesive, and joining process) on joint mechanical properties is complex and there is an interaction between these variables (Ibrisevic et al. 2021).

The paper investigated the bending strength and E modulus of four types of end-to-end grain joints. The objectives were to determine the difference between the basic mechanical properties of profile-adhesive joints suitable for wood lengthening, particularly, to investigate the mechanical properties of puzzle joints. The study aimed to explore the capabilities and limitations of applications of the puzzle joint in the construction of solid wood furniture.

2. MATERIALS AND METHODS

Figure 1 shows the specimens and types of end-to-end grain joints that were taken from manufacturing process and investigated in this study. The specimens had the same geometry configurations of the beam (500x50x30 mm) with four different types of joints: finger joint, tenon joint, dowel joint, and puzzle joint. All elements of the joints were made of common oak wood (*Quercus robur* L.) while dowels were made of beech wood (*Fagus sylvatica* L.). The moisture content and density of the wood were determined as given by ISO 13061-1 (2014) and ISO 13061-2 (2014) after joint testing. The average value of moisture content and density of the wood were 8.6 % and 0.73 g/cm^3, respectively. The joint elements were glued by PVA-c adhesive (requirements of D3 group adhesives) at ambient conditions and with applied pressure.

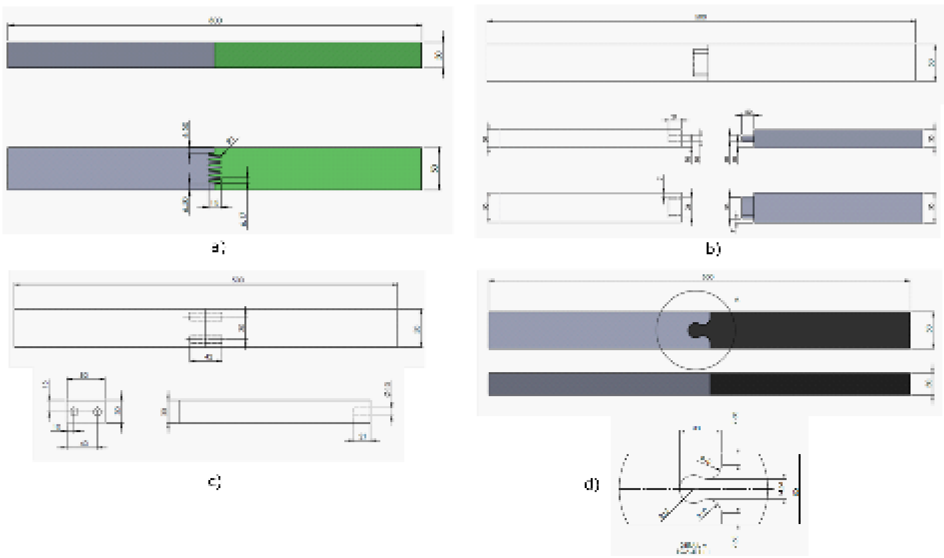


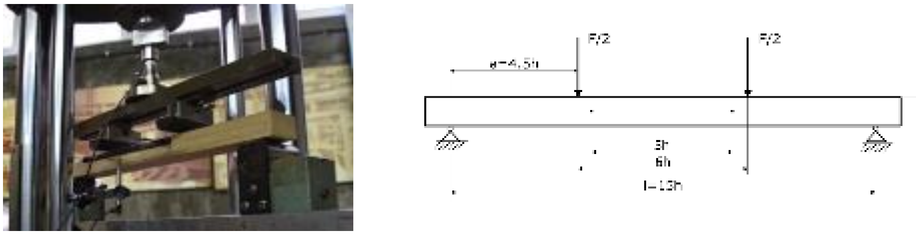
Figure 1. End-to end grain joints: a) finger joint, b) tenon joint, c) dowel joint, d) puzzle joint

The specimens were left in place for fourteen days before being tested on a universal testing machine (Zwick 1282). The four-point test bending and symmetrical loading patterns were used to investigate the mechanical properties of the end-to-end grain joints. The testing model setup (EN 408:2010) is shown in Figure. 2, in which the depth of the cross section in a bending test was $h = 30$ mm. The force and displacement were measured simultaneously until a joint failure. The four-point test bending strength and E modulus were tested on five specimens for each type of end-to-end grain joints.

The bending strength of the joints was calculated by:

$$\sigma_f = \frac{a\,F_{max}}{2\,W} \quad (1)$$

where a is distance between a loading position and the nearest support ($a = 4.5 \cdot h = 135$ mm), F_{max} maximum load in N, W section modulus in mm^3.



a) *b)*

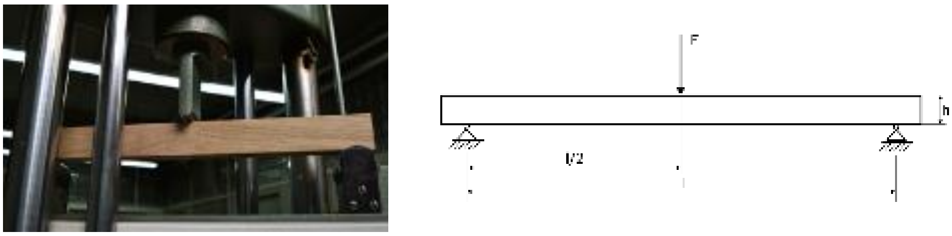
Figure 2. Four-point bending test: a) set-up of joint specimen in testing machine, b) diagram of loading

The modulus of elasticity in bending of the joins was calculated by:

$$E = \frac{a\, l_1{}^2\, (F_2 - F_1)}{16\, I\, (w_2 - w_1)} \quad (2)$$

were l_1 is gauge length for determination E modulus ($l_1 = 5h = 150$ mm), $F_2 - F_1$ an increment of load on the straight-line portion of the load curve in N, $w_2 - w_1$ the increment of deformation corresponding to increment of load in mm, I second moment of area in mm^4.

The three-point test bending strength was tested on one specimen for each type of end-to-end grain joints. The testing model setup is shown in Figure. 3, in which the depth of the cross section in a bending test was $h = 50$ mm.



a) *b)*

Figure 3. Three-point bending test: a) set-up of joint specimen in testing machine, b) diagram of loading

The bending strength of the joints was calculated by:

$$\sigma_f = \frac{F_{max}\, l}{4\, W} \quad \text{MPa} \quad (3)$$

where l is span in bending ($l = 450$ mm).

3. RESULTS AND DISCUSSION

The results of the four-point bending strength and E modulus of oak wood beam specimens with different end-to-end grain joint types are given in Table 1. The bending strength mean value of the finger joints was higher than the mean values of all other types of joints. The bending strength of tenon joints reaches 26.3%, dowel joints, 23.2%, and puzzle joints 32.4%

the bending strength value of the finger joints. These results match the data in the literature, which claim that the finger joint has a larger bending strength compared to other end-to-end grain joints (Khelifaa et al. 2015). The puzzle joints (CV 45.7%) turned out to exhibit very high variability, whereas the finger joints (CV 6.0%) were characterised by the lowest variability.

Table 1. Results of the four-point bending test of four types of end-to-end grain joints

Joint	F_{max}, N		M_{max}, Nm		Bending strength			E modulus		
	Mean	SD	Mean	SD	Mean, MPa	SD, MPa	CV, %	Mean, MPa	SD, MPa	CV, %
Finger	6390.2	426.6	431.3	28.8	59.8	3.6	6.0	2178.7	211.9	9.7
Tenon	1683.4	239.1	113.6	16.1	15.7	2.3	14.3	2023.4	149.7	7.4
Dowel	1510.7	299.0	102.0	20.2	13.9	2.6	18.9	1952.5	434.3	22.2
Puzzle	2081.7	955.7	140.5	64.5	19.4	8.9	45.7	1423.5	800.4	56.2

(SD – standard deviation, CV – coefficient of variation)

Comparative distributions of the bending strength results of the tested types of joints, i.e. finger, tenon, dowel, and puzzle joints, are shown in Figure 4. There is a significant difference between the finger joint bending strength and the other tested joint types. A significant difference was not demonstrated between bending strength for the tenon joints, dowel joints, and puzzle joints. Larger ranges for the puzzle joints group indicate a wider distribution of the bending strength results.

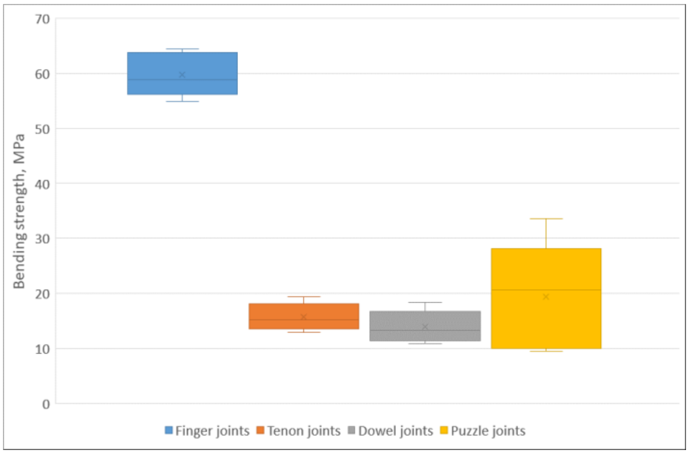


Figure 4. Distribution of bending strength results of end-to end grain joints

The characteristic pattern of the fractures of finger joints and puzzle joints is shown in Figure 5. The common fracture occurred in finger joints i.e. finger extraction with a combination of adhesive and wood failure, while the fracture of puzzle joints occurred when the bond-line failed. The comparative distribution E modulus results of the tested types of joints are shown in Figure 6. The E modulus mean value of the finger joints was 7.7%, 11.6%, and 53.0% higher than the mean values of the E modulus for the tenon joints, dowel joints, and puzzle joints, respectively.

a) *b)*

Figure 5. Characteristic joint failures: a) finger joints, b) puzzle joints

A significant difference was not demonstrated between the E modulus for all tested types of joints. Large ranges for the dowel and puzzle joints groups indicate a wide distribution of the E modulus results.

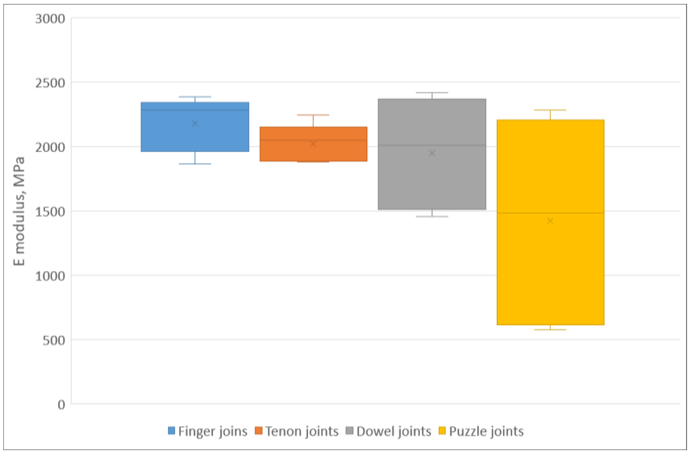


Figure 6. Distribution of E modulus results of end-to end grain joints

The results of the three-point bending strength of oak wood beam specimens with different end-to-end grain joint types (one specimens) are given in Table 2.

Table 2. Results of the three-point bending test of four types of end-to-end grain joints

Joint	W, mm^3	F_{max}, N	M_{max}, Nm	Bending strength, MPa
Finger	12003.7	5101.2	573.9	47.8
Tenon	11991.2	1471.5	165.5	13.8
Dowel	12238.1	1471.5	165.5	13.5
Puzzle	12003.4	1079.1	121.4	10.1

The bending strength value of the finger joints was higher than the values of all other types of joints. The bending strength of tenon joints reaches 28.7%, dowel joints, 28.2%, and puzzle joints 21.1% the bending strength value of the finger joints.

4. CONCLUSION

This paper analysed the bending strength and E modulus of four types end-to-end grain joints in the construction of solid wood furniture. All specimens had the same geometry, while the wood lengthening joints were finger joint, tenon joint, dowel joint, and puzzle joint.

The results showed that finger joints had much higher bending strength than other tested joint types which, however, did not demonstrate a significant difference between each other. Also, significant differences between E modulus were not determined for all tested joint types.

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REFERENCES

1. Barboutis, I.; Vasileiou, V. (2013): Strength of finger - jointed beech wood (Fagus Sylvatica) constructed with small finger lengths and bonded with PU and PVAc adhesives. Pro Ligno, Vol. 9 No 4 2013, pp. 359-364.
2. Ibrisevic, A.; Obucina, M.; Hajdarevic, S.; Mihulja, G. (2021): Influence of moisture content on the strength of finger joints bonded beech wood. In: Proceedings of the 32nd DAAAM International Symposium, pp.0270-0274, Vienna, Austria. DOI: 10.2507/32nd.daaam.proceedings.038
3. Khelifaa, M.; Lahouara, M.A.; Celzardb, A. (2015): Flexural strengthening of finger-jointed Spruce timber beams with CFRP. Journal of Adhesion Science and Technology, 2015 http://dx.doi.org/10.1080/01694243.2015.1057395
4. Larsson, M.; Yoshida, H.; Umetani, N.; Igarashi, T. (2020): Tsugite: Interactive Design and Fabrication of Wood Joints. In: Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology. UIST '20, October 20–23, 2020, Virtual Event, USA. http://dx.doi.org/10.1145/3379337.3415899
5. ***: EN 408 (2010): Timber structures - Structural timber and glued laminated timber - Determination of some physical and mechanical properties.
6. ***: Iso standard 13061-1 (2014): Physical and mechanical properties of wood -Test methods for small clear wood specimens - Part 1.
7. ***: Iso standard 13061-2 (2014): Physical and mechanical properties of wood -Test methods for small clear wood specimens - Part 2.

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