

Article

Proposing Green Growth Indicators for Enterprises in the Woodworking and Furniture Industry

Mariana Sedliačiková , Marek Kostúr and Mária Osvaldová * 

Faculty of Wood Sciences and Technology, Technical University in Zvolen, T. G. Masaryka 24,
960 01 Zvolen, Slovakia; sedliacikova@tuzvo.sk (M.S.); xkosturm@is.tuzvo.sk (M.K.)

* Correspondence: xosvaldova@is.tuzvo.sk; Tel.: +421-907-354-603

Abstract

The increasing emphasis on environmental protection, climate change mitigation, and the transition to a circular economy requires industries, including the wood-processing sector, to integrate sustainability into strategic and operational management. Green growth indicators represent essential tools for evaluating the environmental, economic, and social impacts of business activities, while also contributing to the sustainable economics and responsible management of forest resources and products. This study applies a qualitative research design using structured interviews with 10 executives from medium and large woodworking enterprises in Slovakia. The interviews examined company strategies, practices, and challenges in sustainable development and forest resource utilization. The findings reveal that while many companies actively manage waste, invest in green technologies, and conduct internal audits, the broader implementation of environmental management systems and the uptake of public sustainability funding remain limited. Notably, 90% of respondents emphasized waste volume and recovery rates as critical indicators. Based on the results, a set of green growth indicators was developed and categorized across key thematic areas including waste management, energy efficiency, stakeholder communication, certification, and strategic planning. These indicators not only support the assessment of corporate sustainability but also strengthen efficient forest resource management, responsible use of raw materials, and the long-term economic viability of the sector. The study highlights the importance of systematically designed and practically applicable indicators for guiding companies toward sustainable competitiveness and emphasizes the need for stronger institutional support, improved access to reliable data, and integration of sustainability metrics into core business decision-making.

Keywords: woodworking industry; green growth indicators; sustainable forest; resource management



Academic Editors: Francisco Manuel Parejo-Moruno, Antonio Miguel Linares Luján, José Francisco Rangel Preciado, José Álvarez-García and Carlos Manuel Faísca

Received: 29 September 2025

Revised: 20 October 2025

Accepted: 22 October 2025

Published: 24 October 2025

Citation: Sedliačiková, M.; Kostúr, M.; Osvaldová, M. Proposing Green Growth Indicators for Enterprises in the Woodworking and Furniture Industry. *Forests* **2025**, *16*, 1629.

<https://doi.org/10.3390/f16111629>

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The growing emphasis on nature protection, climate change mitigation, and the transition to a circular economy is prompting industrial sectors, including the woodworking sector, to integrate environmental considerations into their strategies [1,2]. In this context, green growth indicators are gaining prominence as measurable metrics that assess the environmental, economic, and social impacts of corporate activities [3,4]. Their implementation makes it possible to monitor sustainability, optimise production processes, and simultaneously strengthen firms' market position. The authors [5–7] emphasise the need for the systematic measurement of environmental capital, quality of life, and natural

resources as part of the broader framework of sustainable growth. According to [8–10] it is therefore appropriate to monitor resource productivity, the state of natural capital, and the implementation of environmental policies as foundational pillars of an environmentally oriented economy.

In the woodworking industry, green growth indicators are of particular importance given the sector's reliance on renewable yet finite natural resources [11,12]. Properly defined metrics contribute to the protection of forest ecosystems, more efficient use of raw materials, and the reduction of CO₂ emissions [13–15], while simultaneously reflecting dimensions of competitiveness and cost efficiency. Firm-level indicators such as carbon footprint and energy intensity connect economic performance with environmental impacts, and prioritizing certified inputs supports sustainable forest management [16–18]. These approaches are compatible with the FAO Global Forest Resources Assessment and the FOREST EUROPE criteria [19–21], which are widely implemented across European states and enable international comparability. The Nordic countries, in particular, have accumulated substantial experience in integrating the bioeconomy, the circular economy, and forestry [22–24], with Slovak enterprises able to directly map their indicators onto pan-European frameworks [25,26].

However, the implementation of green growth indicators in practice faces several barriers. According to [27–29] most Slovak enterprises have not yet implemented environmental management systems or obtained the relevant certifications, while public subsidies and European grants remain frequently underutilized due to administrative constraints [30,31]. International research demonstrates a positive relationship between environmental innovations and economic performance [32–34]. For these reasons, it is necessary to analyze the applicability of green growth indicators within the Slovak woodworking and furniture industry, identify the specific indicators, evaluate implementation barriers, and design a framework for the systematic monitoring of corporate environmental performance [13,35,36]. As the authors point out [12,37,38], sustainability and green growth are becoming fundamental determinants of competitiveness, while the woodworking sector, as a major user of renewable resources, has a significant impact on biodiversity, the carbon balance, and the state of natural resources. Without systematic monitoring through green growth indicators, it is not possible to objectively assess firms' environmental performance or to formulate effective strategies that support sustainable development and competitiveness in this industry [39–41].

The aim of this study is to establish green growth indicators for firms in Slovakia's woodworking and furniture industry, derived from the results of structured interviews with company management.

In line with the objective, the research questions were formulated as follows:

1. Which environmental, social, and economic indicators can be applied to comprehensively assess green growth in enterprises within the woodworking and furniture industry?
2. How do company executives interpret and use environmental, social, and economic indicators when evaluating green growth and sustainability in practice?

2. Materials and Methods

2.1. Respondent Selection

The study focuses on selected large and medium sized enterprises in the woodworking and furniture industry that are recognized as market leaders in Slovakia based on market share [42,43]. The medium sized companies were not among the market leaders, they showed stable growth and maintained positive financial performance during the research period. A total of ten semi structured interviews with companies were conducted between September 2023 and November 2023. Respondent selection followed purposive

sampling [44,45]. Micro and small enterprises were excluded because the tracked variables are typically not recorded regularly and consistently in this group, which would have resulted in a high share of missing data. Within the purposive sampling procedure, the research objective and questions were first specified in detail. Explicit inclusion criteria were then defined, most notably the classification of firms within the relevant SK NACE sectors. In the next step, eligible cases were identified through existing databases, professional associations, and expert referrals, retaining only those that met the stated conditions. Subsequently, selected respondents were contacted directly with a clear explanation of the study purpose and participation requirements to encourage cooperation [11,22,44]. After data collection, the suitability of the sample was verified by checking that all participants met the inclusion criteria and contributed to the research aim. Finally, the entire sampling process was documented transparently, including the sources consulted and reasons for exclusions, to ensure methodological consistency, result credibility, and replicability in future studies [46–48]. A total of 15 enterprises were contacted, five in SK NACE C16, five in C31, and five in C17. The sample consisted of 15 purposefully selected companies from a population of approximately two thousand seven hundred, representing diverse ownership structures and levels of environmental engagement. Since the research was qualitative, the goal was not statistical generalization but an in-depth understanding of patterns and behaviors within family businesses wood and furniture enterprises, with the sample size determined by data saturation. A detailed specification of the firms that consented to interviews for scholarly purposes is provided in Table 1. All interviews were conducted anonymously; therefore, company names are not disclosed.

Table 1. Characteristic of respondents.

Enterprise	SK NACE *	Legal Form	Size of Enterprise
1	C16	Ltd.	large
2	C16	Ltd.	middle
3	C16	Ltd.	large
4	C16	Ltd.	large
5	C31	cooperative	middle
6	C31	Ltd.	large
7	C31	Ltd.	large
8	C17	JSC	large
9	C17	Ltd.	large
10	C17	JSC	large

* C16 = Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials. C17 = Manufacture of paper and paper products. C31 = Manufacture of furniture.

2.2. Questions Asked

Data was collected through structured interviews with company executives. During each interview, the executive answered 20 questions, as listed in Table 2. The interviews focused on green growth areas in the woodworking, furniture, and pulp and paper industries, examining whether firms have an environmental strategy, how they approach energy efficiency and the use of renewable sources, and what practices they employ for waste sorting and reduction.

Table 2. Interview questions.

Question No.	Questions
1.	How do you ensure that inputs to your production (transformation) process are sustainable?
2.	Do you have long-term business partners?

Table 2. *Cont.*

Question No.	Questions
3.	Do you verify whether your business partners operate sustainably?
4.	Do you verify whether your suppliers use sustainable inputs and have sustainable production processes?
5.	Do you have staff specifically trained to ensure sustainability?
6.	Are your production processes designed to reduce emissions and the amount of waste generated?
7.	Do you seek to eliminate toxic and hazardous substances from your production processes?
8.	Do you conduct internal audits to evaluate the effectiveness of sustainability norms and processes?
9.	Do you minimize waste generation?
10.	Do you utilize the waste that is generated?
11.	How can citizens or employees report environmental complaints to your company?
12.	Which green growth indicators that you can influence are implemented in your company?
13.	After what time horizon did the introduction of sustainable technologies become effective in improving company performance?
14.	Do you believe that, in the long term, it will not be possible to sell products that are not produced sustainably?
15.	Do you use subsidies or other public funds offered by the state or the European Union to support corporate sustainability?
16.	Do you use targeted tools to promote products made according to sustainability principles? If yes, which ones?
17.	Do you have internal regulations that guide efforts to reduce environmental impacts and enhance sustainability?
18.	What actions do you take beyond compliance with existing standards and green growth indicators in the area of environmental protection?
19.	What would help your further development in the context of sustainable development?
20.	What are your future plans to ensure the long-term sustainability of your company?

2.3. Specifics of Indicator Selection

Green growth indicators for the woodworking and furniture industry in Slovakia must be tailored to the sector's specifics, which include working with renewable yet limited raw materials. A key aspect is the share of material by products such as offcuts and sawdust with potential for further use. The industry is also energy intensive but can draw on biomass and other more sustainable energy sources. There is clear scope for material recycling, environmental certification, and the adoption of environmentally friendly management practices [12,19]. Accordingly, indicators should track the rate of recycling and byproduct use, energy consumption and energy mix, corporate carbon footprint, the share of certified inputs, the payback of environmental investments, and the adoption of long-term sustainability strategies [26,49].

The selection of indicators was derived from a thematic analysis of ten structured interviews with representatives of medium-sized and large enterprises in the woodworking and furniture industry. Interview recordings were transcribed into written form and subjected to a rapid accuracy check. The analysis combined inductive coding, where codes emerged directly from the data, with deductive coding based on predefined thematic domains: waste, energy, internal audits, complaints, and subsidies. The Taguette software in version 1.4.1 was used to code the interviews and build the coding scheme; it enabled

systematic text coding, the creation of a codebook, and the clustering of meaning categories in line with the objectives of the qualitative study [6]. After processing the first three transcripts, a working mini codebook with operational definitions of codes and illustrative textual cues was produced, and all remaining interviews were coded on this basis [50–52].

To strengthen procedural credibility, peer debriefing was conducted on contested points of interpretation, and all revisions to the codebook were logged on an ongoing basis [53–55]. Thematic saturation was reached after the ninth interview and confirmed by the tenth, beyond which no new meaning categories emerged beyond the original domains. The coding output consisted of clustering segments by frequency of occurrence, practical salience, and the feasibility of measurable operationalization [56–58].

From the consolidated themes, selected indicators were derived and assessed. Four criteria guided their selection: relevance to sustainability and firm performance, measurability and data availability under limited information-technology capacity, time to result for managerial decision-making, and comparability across firms and overtime. The final set comprises five indicators with unambiguous definitions, measurement units, and computational formulas [35,59]. They cover the areas identified by respondents and enable ongoing, time-consistent monitoring of sustainability in enterprises in the woodworking and furniture industry [60,61].

3. Results

3.1. Respondents Answers

The research findings indicate that woodworking enterprises consistently report efforts to efficiently valorize production waste, particularly sawdust, which is further processed into briquettes or supplied as feedstock to other entities. One company exemplifies a notably innovative practice by converting wood waste into energy through its own power plant. The electricity produced covers internal energy needs and is partially fed into the public distribution grid. This model both reduces waste and supports the use of renewable energy sources.

The interviews further show that companies most often monitor the volume of generated waste and air quality, and they implement various forms of environmental innovation. Less common is the adoption of comprehensive environmental management instruments such as environmental management systems, green public procurement, or environmental product labeling. This indicates untapped potential to strengthen a systematic approach to environmental management.

Ninety percent of respondents reported conducting internal environmental audits, indicating a high level of organizational maturity and a systematic effort to improve environmental performance within sustainable development.

More than half of the companies implemented voluntary environmental initiatives that go beyond legal requirements, such as installing solar panels, using rail transport, planting trees, and operating in-house wastewater treatment facilities. These measures signal strong environmental awareness and a responsible approach to corporate social responsibility.

The findings also show that over half of the firms adopted mechanisms that allow employees and the public to submit complaints anonymously, most commonly through suggestion boxes, email communication, and telephone hotlines. One respondent introduced a fully structured system for handling complaints, including feedback to submitters and thorough investigation of reported issues.

The responses confirmed that for seven out of ten companies the implementation of sustainable technologies proved effective within a time horizon of one to five years. One company reported positive results in less than one year, which points to the potential for rapid payback from innovation and environmentally oriented solutions.

It was found that seven out of ten firms believe that in the long term non-sustainable production will be incompatible with market viability. This stance reflects growing consumer pressure for environmentally responsible practices and highlights sustainability as a strategic source of competitive and marketing advantage.

The analysis revealed differences between large and medium sized enterprises in how they communicate environmental responsibility. Large firms, especially in the pulp and paper segment, actively promote the environmental attributes of their products through advertising, audiovisual materials, and eco labels. By contrast, medium sized companies undertake such activities only sporadically, which can be attributed mainly to limited financial and human resources.

The results also showed that despite the availability of several support schemes from the state and the European Union, only one company actually used grants. Administrative complexity and unclear eligibility rules often act as barriers, reducing firms' motivation to apply for public funding.

3.2. Proposed Indicators

Based on insights identified during interviews with representatives of woodworking enterprises, a set of indicators can be proposed to form a foundational framework for constructing a sectoral system for assessing environmental sustainability, as listed in Table 3. The proposed indicators should be systematically grouped into thematic domains that reflect environmental performance and the commitments of individual entities.

In waste management it is most relevant to track the share of energy recovery relative to the amount of waste sent for disposal, as this reveals the environmental preference for processing residual materials. Additionally, it is advisable to monitor the share of recycled materials in the total waste stream and the degree of internal recovery within the production cycle, which indicate the efficiency of material management. This links to product sustainability, which can be assessed by the share of output produced from certified or recycled inputs. The breadth of environmental certifications also reflects the level of trust from the market and from regulatory authorities.

A higher share of recycled materials directly reduces demand for primary wood and thus the pressure on harvesting and interventions in stands. Using recycled materials also supports cascading use of wood and better adherence to the principle of sustainable yield. Transparent communication about wood origin and channels for submitting complaints reduces the risk of illegal logging, and communication itself creates market pressure for sustainable forest management.

Regular internal audits of procurement and input traceability strengthen discipline in meeting sustainable forest management standards; when audits lead to corrective actions, the findings translate into tangible benefits for forest resources. Voluntary initiatives beyond legal requirements bring a direct positive effect on forest conditions and speed up the adoption of sustainable practices where the regulatory framework is not sufficient. Long-term planning with five- to ten-year targets for recycling, certified inputs, and carbon and energy performance shapes future demand for primary wood in line with sustainable yield; through such planning, timber withdrawals from forests are stabilized and space is created for close to nature silviculture.

Table 3. Proposed indicators and their measurement method.

Indicators	Measurement	Unit	Methodological Note on Measurement
Use of recycled materials	Share of recycled materials	% (weight fraction)	Weight of recycled materials/total weight of inputs $\times 100$; report annually. Data from production records.
	Energy intensity	kWh/m ³ finished product or MJ/t	Total energy consumption (electricity, heat)/volume or weight of production; includes both renewable and non-renewable resources.
	Return on investment	%/year or years of payback	IRR or ROI from green investments; data from financial statements, normalized to a given project.
Communication	Number of certificates used	ks	Number of valid certificates (ISO 14001 *, FSC, PEFC, EMAS); indicate the status as of 31.12. of the given year.
	Share of complaints received and resolved	%	Number of resolved complaints/number of complaints received $\times 100$; annual average.
	Percentage of investment in marketing	%	Eco-friendly marketing budget/total marketing budget $\times 100$.
Internal audit	Audit frequency	pcs/year	Number of internal environmental audits carried out during the year; recorded in internal protocols.
	Rate of implementation of recommendations	%	Number of implemented recommendations/total number of audit recommendations $\times 100$; evaluate annually.
Voluntary initiative	Reduction of CO ₂	t CO ₂ /year CO ₂ /m ³	Difference between CO ₂ emissions in the monitored year and in the reference year; emissions calculated according to the IPCC or GHG Protocol methodology.
	Share of new wood raw material in the final product	%	Weight of raw (non-certified, non-recycled) wood/total weight of product $\times 100$.
Long-term planning	Creation and application of strategies	pcs/year	Number of officially approved strategic documents in the field of sustainability that are actively implemented.
	Fulfilling the set goals	%/year	Percentage of goals defined in the strategic plan that have been met; assessed at the end of the year.

* ISO 14001 [62].

Waste management and energy recovery were recognized as the most direct indicators of sustainability with clear financial outcomes. However, communication with stakeholders and the promotion of sustainable practices can also bring long-term benefits. Further research should focus on understanding how these activities influence customer perception and business performance, helping companies link sustainability communication with measurable economic results.

4. Discussion

The woodworking industry has the potential to advance toward greater sustainability, but this process requires systematic measurement through green growth indicators. The

research results showed that most firms already apply various measures in waste management, energy efficiency, and stakeholder communication. To evaluate these activities over time, it is essential to operationalize them into measurable indicators that allow comparison across companies and across the sector.

Respondents repeatedly reported using waste materials, especially sawdust, and further processing them through briquetting or energy recovery [16,22]. One company reported operating its own power plant to process wood waste, which contributes to energy self-sufficiency and also feeds electricity into the grid. These approaches are consistent with findings reported in the literature [27,39], according to the literature, recycling and energy recovery reduce the volume of waste, the consumption of raw materials, and emissions. An indicator that measures the share of recycled inputs together with the energy intensity of production, expressed in kilowatt hours per cubic meter of product, is therefore well founded [63,64]. When interpreting this indicator, it is essential to distinguish between material recycling and energy recovery, since the environmental benefit depends on the chosen system boundaries and on the substitution effect [65–67].

More than half of the companies have introduced mechanisms for receiving environmental submissions from employees and the public. The most common channels are suggestion boxes, email, and telephone hotlines, and one company operates a structured system that provides feedback to complainants [17,46]. The literature [68,69] consider the number of received and resolved complaints a qualitative indicator of transparency, and it emphasizes the importance of formal channels for reporting and follow-up [4,70]. The “rate of resolved complaints” indicator defined as the percentage of resolved cases out of all received is suitable for tracking corporate trustworthiness and accountability, and it can be complemented by case-closure time as a qualitative parameter.

Several enterprises use certified inputs or hold management system certifications (ISO 14001, FSC, PEFC, EMAS). According to [16,32] certification supports customer orientation, enhances reputation, and eases access to environmentally focused investment. The indicator number of certificates as of 31 December of the given year is therefore appropriate, though it is necessary to account for certification costs and the risk of purely formal compliance without genuine improvement, which some studies describe as greenwashing [35,71]. In some cases, companies obtained certifications mainly due to supply chain requirements or customer expectations rather than as evidence of measurable environmental progress. This suggests that certifications function more as formal and communicative tools than as direct indicators of sustainability, although they still contribute to promoting transparency and responsible management practices [72].

Seven out of ten companies reported that the payback period for environmental investments materialized within a time horizon of one to five years, while one company reported less than one year. These findings are broadly consistent with the literature [5], which reports an average payback of four to five years depending on the type of investment. A payback indicator such as ROI or IRR therefore captures the economic dimension of sustainability, which is essential when evaluating investments in profit oriented firms [26,60]. However, the calculations should also account for external effects, for example the use of subsidies or tax allowances.

The results showed that only one company used the available grants or subsidies, which stands in contrast to the literature [19,39], which describes the positive effects of these instruments in terms of reducing investment risk. In the Slovak context, respondents cited administrative burden as the main barrier [54–56]. This corresponds with the finding [63,73], that European funds also carry risks of opacity or corruption. An indicator tracking the use of subsidies is therefore not only an economic metric but also an indicator of companies' ability to respond to policy incentives [74–76].

Nine out of ten companies conduct an internal environmental audit. According to [18,53,77] an audit is a key element of environmental management that improves resource use and supports an ecological trajectory. The indicators number of audits per year and rate of implementation of audit recommendations provide an appropriate means of tracking continuous improvement [78,79].

More than half of the respondents implement measures that go beyond statutory requirements, such as installing solar panels, using rail transport, planting trees, and operating wastewater treatment facilities. According to [39,63], voluntary environmental initiatives are positively valued by the market, particularly when they are paired with regulatory incentives and demonstrable outcomes. Indicators of such initiatives, for example a reduction in CO₂ relative to a baseline year, therefore signal a proactive stance and an ability to adapt to evolving market requirements [80,81].

Respondents who apply strategic planning over a five to ten year horizon report better outcomes in energy efficiency and a lower carbon footprint [81]. Similarly [27,82] emphasize the importance of long-term strategies for the systematic reduction in environmental impacts and for strengthening credibility. The indicator number of approved strategies and achievement of set targets thus makes it possible to track the continuity and transparency of sustainable management [83–85].

Practical application confirmed that collecting the proposed indicators is neither financially nor technically demanding and that they are clearly defined and measurable [86,87]. Their number is adequate and covers the environmental, economic, and social dimensions, which helps avoid a fragmented approach. Nevertheless, the study is limited by purposive sampling, the exclusion of micro and small enterprises, and the self-reported nature of responses, which may introduce recall or reputation bias [88,89]. The results should therefore not be generalized to the entire sector without further verification and external validation.

5. Conclusions

The study confirmed that sustainability in the woodworking industry can be monitored systematically through a set of green growth indicators. The key indicators are the share of recycled materials, communication with employees and the public, certifications attesting to environmental commitments, the return on environmental investments, the frequency of internal audits, voluntary initiatives beyond legal requirements, and long-term sustainability planning. Together these indicators provide a practical framework for measuring environmental performance, strengthening transparency, and enabling better resource management, thereby contributing to more resilient development of individual firms and the sector.

However, the study has limitations. The sample included only medium and large enterprises, so the perspectives of micro- and small firms, which constitute a substantial share of the industry, were not captured. Data was collected through structured interviews, which introduces the risk of subjective bias and self-presentation. The relatively small number of respondents further limits the generalizability of the findings to the entire sector. These limitations should be considered when interpreting the results and when planning future research.

Despite these limitations, the findings have practical value for enterprises and for public policymakers. The identified indicators are financially and technically undemanding and can therefore be implemented even in settings with limited capacity. Enterprises are advised to establish a unified methodology with standardized templates, designate a responsible person for recording the indicators, and evaluate the return on environmental investments at least once a year. Public policy should support implementation through joint training, methodological guides, unified reporting channels, financial vouchers for external

audits, and access to shared services via professional associations. In the international context, it is advisable to map simple local metrics to global reference frameworks to ensure data comparability and traceability of wood origin across value chains.

The research thus provides a foundation for the systematic assessment of the environmental performance of the Slovak woodworking industry. The identified indicators integrate the environmental, economic, and social dimensions of sustainability and offer a tool that can contribute to better resource management, enhanced competitiveness, and the long-term sustainability of the sector.

Author Contributions: Conceptualization, M.S., M.K. and M.O.; methodology, M.S., M.K. and M.O.; software, M.K. and M.O.; validation, M.S.; formal analysis, M.S., M.K. and M.O.; investigation, M.S., M.K. and M.O.; resources, M.S., M.K. and M.O.; data curation, M.S., M.K. and M.O.; writing—original draft preparation, M.S., M.K. and M.O.; writing—review and editing, M.S., M.K. and M.O.; visualization, M.S., M.K. and M.O.; supervision, M.S., M.K. and M.O.; project administration, M.S., M.K. and M.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by projects VEGA no. 1/0011/24, APVV-18-0520, APVV-21-0051, APVV-22-0238, APVV-23-0116, COST CA23117, COST CA23157 also this research was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V05-00016 (IPA ESG no. 3/2024, IPA ESG no.4/2024).

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to privacy.

Acknowledgments: The authors are thankful to IPA ESG 03/2024.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Bakkes, J.A.; van den Born, G.J.; Helder, J.C.; Swart, R.J.; Hope, C.W.; Parker, J.D.E.; Downing, T.E. Indicators in Environmental Health: Identifying and Selecting Common Sets. *Tijdschr. Voor Milieukd.* **1994**, *9*, 130–144.
2. Kabaklarlı, E. Green Growth and Circular Economy: Panel Cointegration Analysis for OECD Countries. *Sustainability* **2022**, *14*, 12555.
3. Khoe, B.N.; Phuong, N.H. Developing a Circular Economy Contributes to Promoting Green Growth in Vietnam. *Sustainability* **2024**, *16*, 3792.
4. Korneliuk, H. Directions of Circular Economy Implementation in the Wood Processing Industry in Ukraine. *Energies* **2024**, *17*, 1512.
5. Acosta, L.; Maharjan, P.; Peyriere, H.M.; Mamiit, R. Natural capital protection indicators: Measuring performance in achieving the Sustainable Development Goals for green growth transition. *Environ. Sustain. Indic.* **2020**, *8*, 100069. [[CrossRef](#)]
6. Agrawal, S.; Ray, A.; Rana, N.P. Effectiveness of Sustainability Communication on Stakeholder Engagement: A Multi-Method Qualitative Assessment. *Corp. Soc. Responsib. Environ. Manag.* **2025**, *32*, 820–834. [[CrossRef](#)]
7. Goldhahn, C.; Cabane, É.; Chanana, M. Sustainability in wood materials science: An opinion about current material development techniques and the end of lifetime perspectives. *Philos. Trans. R. Soc. A* **2021**, *379*, 20200339. [[CrossRef](#)]
8. David, B.; Ősz, O.; Hegyháti, M. Robust Scheduling of Waste Wood Processing Plants with Uncertain Delivery Sources and Quality. *Sustainability* **2021**, *13*, 5007. [[CrossRef](#)]
9. Niameshchuk, H.; Bozhanova, V.; Chala, V.; Hlushchenko, A. The environmental and resource productivity as the key element of green economy in EU. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *915*, 012018. [[CrossRef](#)]
10. He, Y.; Dai, J. Dissecting the relationship between fin-tech indicators, natural resources and green productivity in ASEAN: Regarding human development and globalization perspectives. *Front. Environ. Sci.* **2025**, *13*, 1576038. [[CrossRef](#)]
11. Druica, E.; Válsán, C.; Puiu, A.-I. Voluntary Simplicity and Green Buying Behavior: An Extended Framework. *Energies* **2022**, *15*, 1889. [[CrossRef](#)]
12. Michal, J.; Březina, D.; Šafařík, D.; Babuka, R. Sustainable Development Model of Performance of Woodworking Enterprises in the Czech Republic. *Forests* **2021**, *12*, 672. [[CrossRef](#)]
13. Sedliačiková, M.; Melichová, M.; Stasiak-Betlejewska, R.; Schmidtová, J.; Kocianová, A. Green Growth and Sustainable Development in the Wood-Processing Industry: Evidence from Slovakia. *Pol. J. Manag. Stud.* **2023**, *27*, 20. [[CrossRef](#)]

14. Köhl, M.; Ehrhart, H.; Knauf, M.; Neupane, P.R. A Viable Indicator Approach for Assessing Sustainable Forest Management in Terms of Carbon Emissions and Removals. *Ecol. Indic.* **2020**, *111*, 106057. [\[CrossRef\]](#)
15. Do, T.T.H.; Ly, T.B.T.; Hoang, N.; Tran, V.T. A New Integrated Circular Economy Index and a Combined Method for Optimization of Wood Production Chain Considering Carbon Neutrality. *Chemosphere* **2022**, *311*, 137029. [\[CrossRef\]](#)
16. Engler, D.; Gutsche, G.; Simixhiu, A.; Ziegler, A. On the relationship between corporate CO₂ offsetting and pro-environmental activities in small- and medium-sized firms in Germany. *Energy Econ.* **2022**, *118*, 106487. [\[CrossRef\]](#)
17. Etikan, I.; Musa, S.A.; Alkassim, R.S. Comparison of convenience sampling and purposive sampling. *Int. J. Res. Stud. Educ.* **2016**, *5*, 1–7. [\[CrossRef\]](#)
18. Levin, M. Voluntary Environmental Initiatives in Canadian Manufacturing Sector. Master's Thesis, Ryerson University, Toronto, ON, Canada, 2004. [\[CrossRef\]](#)
19. Christensen, P.H.; Robinson, S.J.; Simons, R.A. Institutional investor motivation, processes, and expectations for sustainable building investment. *Build. Res. Inf.* **2021**, *50*, 276–290. [\[CrossRef\]](#)
20. Farjana, S.H.; Tokede, O.O.; Ashraf, M. Environmental Impact Assessment of Waste Wood-to-Energy Recovery in Australia. *Energies* **2023**, *16*, 4182. [\[CrossRef\]](#)
21. Figiel, A.; Badar, A. Effect of Green Entrepreneurial Orientation and Absorptive Capacity on Green Innovation and Environmental Orientation Among Educated Gen Z's in Europe. *Sustainability* **2025**, *17*, 593. [\[CrossRef\]](#)
22. Borrello, M.; Pascucci, S.; Lombardi, A.; Cembalo, L. Circular Bioeconomy and the Forest–Wood Sector: Bridging the Gap between Policies and Disadvantaged Forest Areas. *Appl. Sci.* **2023**, *13*, 1349. [\[CrossRef\]](#)
23. Haque, F.; Ntim, C. Do corporate sustainability initiatives improve corporate carbon performance? Evidence from European firms. *Bus. Strategy Environ.* **2022**, *31*, 3318–3334. [\[CrossRef\]](#)
24. Refsgaard, K.; Kull, M.; Slåtmo, E.; Meijer, M. Bioeconomy—A Driver for Regional Development in the Nordic Countries. *New Biotechnol.* **2020**, *60*, 130–137. [\[CrossRef\]](#)
25. García-Montero, L.G.; Pascual, C.; Martín-Fernández, S.; Sanchez-Paus Díaz, A.; Patriarca, C.; Martín-Ortega, P.; Mollicone, D. Global Forest Survey (GFS) in the Temperate FAO Region Using Collect Earth. *Remote Sens.* **2021**, *13*, 4344. [\[CrossRef\]](#)
26. Linser, S.; Wolfslehner, B. 25 Years of Criteria and Indicators for Sustainable Forest Management: Still Invaluable, Still Improving. *Forests* **2018**, *9*, 515. [\[CrossRef\]](#)
27. Barratt, M.J.; Ferris, J.A.; Lenton, S. Hidden Populations, Online Purposive Sampling, and External Validity: Taking off the Blindfold. *Field Methods* **2015**, *27*, 3–21. [\[CrossRef\]](#)
28. Dalalah, D.; Khan, S.; Al-Ashram, Y.; Albeetar, S.; Ali, Y.A.; Alkhouli, E. An integrated framework for the assessment of environmental sustainability in wood supply chains. *Environ. Technol. Innov.* **2022**, *27*, 102429. [\[CrossRef\]](#)
29. Petrova, E.; Štofa, T.; Šoltés, M. Exploration of the Factors that Influence the Implementation of Environmental Management Systems—The Case of Slovakia. *Economies* **2021**, *9*, 68. [\[CrossRef\]](#)
30. Repiská, R. EMAS, A PREMIUM TOOL FOR ENVIRONMENTAL MANAGEMENT AND AUDIT IN SLOVAK REPUBLIC. In *Socio-Economic Determinants of Sustainable Consumption and Production II*; University of Economics in Bratislava: Bratislava, Slovakia, 2021.
31. Báliková, K.; Šálka, J. Are Silvicultural Subsidies an Effective Payment for Ecosystem Services in Slovakia? *Land Use Policy* **2022**, *116*, 106056. [\[CrossRef\]](#)
32. Chygryn, O.; Ziabina, Y.; Iskakov, A. Communicative Channels of Stakeholder Interaction as an Element of Ensuring Sustainable Development of the Business Sector. *E3S Web Conf.* **2023**, *456*, 02001. [\[CrossRef\]](#)
33. Wang, M.; Li, Y.; Wang, Z. A Nonlinear Relationship Between Corporate Environmental Performance and Economic Performance of Green Technology Innovation: Moderating Effect of Government Market-Based Regulations. *Bus. Strat. Environ.* **2023**, *32*, 3119–3138. [\[CrossRef\]](#)
34. Liao, Z.; Liu, P.; Liu, S. A meta-analysis of environmental innovation and firm performance. *J. Environ. Plan. Manag.* **2021**, *64*, 2047–2065. [\[CrossRef\]](#)
35. Earnhart, D.H.; Harrington, D.R. Effects of audit frequency, audit quality, and facility age on environmental compliance. *Appl. Econ.* **2021**, *53*, 3234–3252. [\[CrossRef\]](#)
36. Farjana, S.H.; Ashraf, M. Developing the conceptual framework for the key performance indicators for sustainable wood waste supply chain. *Environ. Dev. Sustain.* **2023**, *27*, 6921–6944. [\[CrossRef\]](#)
37. Melichová, M.; Poláková, N.; Moresová, M.; Kocianová, A. Determinants preventing the implementation of green growth and sustainable development in enterprises in the Slovak wood-processing industry. *SHS Web Conf.* **2021**, *129*, 05007. [\[CrossRef\]](#)
38. Hajdúchová, I.; Kristakova, Z. Analysis of Green Growth in Forest Conditions. In *Zero Waste Management and Circular Economy*; ICOM: Paris, France, 2022.
39. Linser, S.; Pülzl, H.; Bastrup-Birk, A. National Implementation of the Forest Europe Indicators for Sustainable Forest Management. *Forests* **2022**, *13*, 191. [\[CrossRef\]](#)

40. Korneliuk, O. Directions of Circular Economy Implementation in the Wood Processing Industry in the Context of Sustainable Development. *Bus. Navig.* **2024**, *74*, 191–197. [\[CrossRef\]](#)
41. Palander, T.; Haavikko, H.; Kortelainen, E.; Kärhä, K. Comparison of Energy Efficiency Indicators of Road Transportation for Modeling Environmental Sustainability in “Green” Circular Industry. *Sustainability* **2020**, *12*, 2740. [\[CrossRef\]](#)
42. Khalil, M.A.; Khalil, R.; Khalil, M.K. Environmental, Social and Governance (ESG)-Augmented Investments in Innovation and Firms’ Value. *China Financ. Rev. Int.* **2024**, *14*, 76–102. [\[CrossRef\]](#)
43. Ahmad, M.; Wilkins, S. Purposive Sampling in Qualitative Research: A Framework for the Entire Journey. *Qual. Quant.* **2024**, *59*, 1461–1479. [\[CrossRef\]](#)
44. Memon, M.; Thurasamy, R.; Ting, H.; Cheah, J. Purposive Sampling: A Review and Guidelines for Quantitative Research. *J. Appl. Struct. Equ. Model.* **2024**, *9*, 1. [\[CrossRef\]](#)
45. Denieffe, S. Commentary: Purposive Sampling: Complex or Simple? Research Case Examples. *J. Res. Nurs.* **2020**, *25*, 662–663. [\[CrossRef\]](#) [\[PubMed\]](#)
46. Kovacevic, M.; Blagojević, S.; Kuzmanović, B. Sustainability of the Motivation Policy Model for Employees in State Administration. *Sustainability* **2020**, *12*, 7974. [\[CrossRef\]](#)
47. Dyson, K.; Dawwas, E. Say where you sample: Increasing site selection transparency in urban ecology. *Ecosphere* **2023**, *14*, e04466. [\[CrossRef\]](#)
48. McKenna, F.; Hanrahan, J. Meaningful Community Engagement through Advanced Indicator Systems for Sustainable Destination Planning. *Environ. Sustain. Indic.* **2024**, *22*, 100392. [\[CrossRef\]](#)
49. Beckmann, A.; Sivarajah, U.; Irani, Z. Circular Economy versus Planetary Limits: A Slovak Forestry Sector Case Study. *J. Enterpr. Inf. Manag.* **2020**, *34*, 1673–1698. [\[CrossRef\]](#)
50. Xu, W.; Zammit, K. Applying Thematic Analysis to Education: A Hybrid Approach to Interpreting Data in Practitioner Research. *Int. J. Qual. Methods* **2020**, *19*, 1609406920918810. [\[CrossRef\]](#)
51. Rampin, R.; Rampin, V. Taguette: Open-Source Qualitative Data Analysis. *J. Open Source Softw.* **2021**, *6*, 3522. [\[CrossRef\]](#)
52. O’Callaghan, C.; Dwyer, J.; Schofield, P. Thematic Analysis Informed by Grounded Theory (TAG) in Healthcare Research: Foundations and Applications. *Qual. Res. Psychol.* **2024**, *21*, 279–306. [\[CrossRef\]](#)
53. Saldaña, J. *The Coding Manual for Qualitative Researchers*, 4th ed.; Sage Publications: London, UK, 2021; pp. 1–368.
54. Wang, X.; Roe, M.; Liu, S. A Qualitative Analysis of Oil Port Sustainability Frameworks. In *Maritime Transport and Regional Sustainability*; Springer: Cham, Switzerland, 2020; pp. 91–118.
55. Fu, H.; Zhou, T.-W.; Zhang, S.; Wang, Q. The Impact of Government Subsidy and Weather on Environmentally Sustainable Investment Decision for Agricultural Supply Chain. *PLoS ONE* **2023**, *18*, e0285891. [\[CrossRef\]](#) [\[PubMed\]](#)
56. Song, L.; Yan, Y.; Yao, F. Closed-Loop Supply Chain Models Considering Government Subsidy and Corporate Social Responsibility Investment. *Sustainability* **2020**, *12*, 2045. [\[CrossRef\]](#)
57. Elliott, L.E.; Petosa, J.; Guiot, A.B.; Klein, M.D.; Herrmann, L.E. Qualitative Analysis of a Virtual Near-Peer Pediatric Boot Camp Elective. *Med. Sci. Educ.* **2022**, *32*, 473–480. [\[CrossRef\]](#)
58. Moura, C.; Silva, Í.R.; da Silva, T.P.; Santos, K.A.; Crespo, M.d.C.A.; da Silva, M.M. Methodological path to reach the degree of saturation in qualitative research: Grounded theory. *Rev. Bras. Enferm.* **2021**, *75*, e20201379. [\[CrossRef\]](#)
59. Saunders, C.H.; Sierpe, A.; von Plessen, C.; Kennedy, A.M.; Leviton, L.; Bernstein, S.; Goldwag, J.; King, J.R.; Marx, C.M.; A Pogue, J.; et al. Practical thematic analysis: A guide for multidisciplinary health services research teams engaging in qualitative analysis. *BMJ* **2023**, *381*, e074256. [\[CrossRef\]](#) [\[PubMed\]](#)
60. Ravitch, S.M.; Carl, N.M. *Qualitative Research: Bridging the Conceptual, Theoretical, and Methodological*; Sage Publications: Thousand Oaks, CA, USA, 2020; pp. 1–384.
61. Wiltshire, G.; Ronkainen, N. A realist approach to thematic analysis: Making sense of qualitative data through experiential, inferential and dispositional themes. *J. Crit. Realism* **2021**, *20*, 159–180. [\[CrossRef\]](#)
62. ISO 14001:2015; Environmental Management Systems—Requirements with Guidance for Use. International Organization for Standardization: Geneva, Switzerland, 2015.
63. Rangel-Preciado, J.F.; Parejo-Moruno, F.M.; Cruz-Hidalgo, E. Rural Districts and Business Agglomerations in Low-Density Business Environments. The Case of Extremadura (Spain). *Land* **2021**, *10*, 280. [\[CrossRef\]](#)
64. Michalak, A.; Filipiak, B.Z. Analysis of the Impact of Reporting in Non-Financial Statements on the Level of Environmental Performance Disclosure. *Sustainability* **2022**, *14*, 13184. [\[CrossRef\]](#)
65. Lalau, Y.; Al Asmi, I.; Olives, R.; Dejean, G.; Meffre, A.; Py, X. Energy analysis and life cycle assessment of a thermal energy storage unit involving conventional or recycled storage materials and devoted to industrial waste heat valorisation. *J. Clean. Prod.* **2021**, *330*, 129950. [\[CrossRef\]](#)
66. Ekvall, T.; Gottfridsson, M.; Nellström, M.; Nilsson, J.; Rydberg, M.; Rydberg, T. Modelling incineration for more accurate comparisons to recycling in PEF and LCA. *Waste Manag.* **2021**, *136*, 153–161. [\[CrossRef\]](#)

67. Moraga, G.; Huysveld, S.; De Meester, S.; Dewulf, J. Resource efficiency indicators to assess circular economy strategies: A case study on four materials in laptops. *Resour. Conserv. Recycl.* **2022**, *178*, 106099. [\[CrossRef\]](#)
68. Septianingsih, I.; Mustofa, H. Implementation of Electronification Whistleblowing System Through the Application of Complaint Service Information at The Jombang Regency Inspectorate. *J. Kebijak. Dan Manaj. Publik* **2025**, *13*, 28–39. [\[CrossRef\]](#)
69. Agustina, A.R.; Rachmawati, T. The Use of Information Communication and Technology (ICT) to Enable Transparency, Accountability, and Participation in Indonesia. In Proceedings of the 2020 IAPA Annual International Conference, Virtual, 11 November 2020; pp. 589–607.
70. Karren, K.; Schmitz, M.; Schaffer, S. Improving Conversational User Interfaces for Citizen Complaint Management through enhanced Contextual Feedback. In Proceedings of the 6th ACM Conference on Conversational User Interfaces, Luxembourg, 8–10 July 2024.
71. Ilić, D.; Mollet, J. Voluntary corporate climate initiatives and regulatory threat. *Int. Econ. Econ. Policy* **2021**, *19*, 157–184. [\[CrossRef\]](#)
72. Cha, H.; Park, H. Mind the Other Gap: Means-Ends Decoupling of Environmental Certification. *Acad. Manag. Proc.* **2020**, *2020*, 13238. [\[CrossRef\]](#)
73. Lv, C.M.; Jue, Y.B.; Guo, X.; Ling, M.H.; Yan, D.H. Research on Quantification Method of Water Pollution Ecological Environment Losses. *Aqua* **2022**, *71*, 709–721. [\[CrossRef\]](#)
74. Výrostová, E.; Nyikos, G. Administrative Capacity and EU Funds Management Systems Performance: The Cases of Hungary and Slovakia. *Reg. Stud.* **2023**, *58*, 704–718. [\[CrossRef\]](#)
75. Vretenar, N.; Filipas, A.M.; Briš Alić, M. Business' Attitudes Towards Corruption in Selected Central European Countries. *Cent. Eur. Public Adm. Rev.* **2023**, *21*, 29–52. [\[CrossRef\]](#)
76. Hintošová, A.B.; Sudzina, F.; Barlašová, T. Direct and Indirect Effects of Investment Incentives in Slovakia. *J. Risk Financ. Manag.* **2021**, *14*, 56. [\[CrossRef\]](#)
77. Odnorih, Z.; Malovanyy, M.; Tkachyk, Y.; Romaniuk, L.; Krusir, G. Internal Environmental Audit of the Enterprise as a Component of Environmental Management. *Environ. Probl.* **2024**, *9*, 150–156. [\[CrossRef\]](#)
78. Zaky, E.; El-Sisi, A. The Role of the Internal Auditor in Increasing the Effectiveness of Environmental Performance to Achieve Economic Development. *J. Environ. Sci.-China* **2020**, *49*, 62–98. [\[CrossRef\]](#)
79. Kassim, S.N.B.; Radzi, N.A.S.M.; Zuraini, N.K.; Roslan, S.A.; Jamil, M.M. The Internal Auditors in Catalyst for Sustainability Performance through Environmental Audit. *Int. J. Res. Innov. Soc. Sci.* **2024**, *VIII*, 1141–1147. [\[CrossRef\]](#)
80. Zameer, H.; Nawaz, M.A.; Khan, M.; Sajid, M. Voluntary Environmental Disclosure and Firm Value in South Asian Economies. *Sustainability* **2021**, *13*, 1236. [\[CrossRef\]](#)
81. Linares Luján, A.M. De la apropiación del usufructo a la privatización de la superficie: Las tierras concejiles en la Baja Extremadura, 1750–1850. *Hist. Agraria Rev. Agric. Hist. Rural* **1995**, *9*, 87–127.
82. Bose, S.; Mondal, A.; Biswas, S.K. Voluntary Carbon Disclosure and Firm Performance: Evidence from Emerging Markets. *J. Clean. Prod.* **2023**, *385*, 135747. [\[CrossRef\]](#)
83. Miao, J.; Guan, Z.; Guo, Y. ESG Performance and Long-Term Corporate Performance. *Adv. Econ. Manag. Political Sci.* **2024**, *126*, 160–167. [\[CrossRef\]](#)
84. Ukpohor, E.T.; Adebayo, Y.A.; Dienagha, I.N. Strategic Asset Management in LNG Plants: A Holistic Approach to Long-Term Planning, Rejuvenation, and Sustainability. *Gulf J. Adv. Bus. Res.* **2024**, *126*, 160–167. [\[CrossRef\]](#)
85. Okoduwa, T.; Giwah, T. Strategic Innovation in Energy Supply Chains: Bridging Efficiency and Sustainability. *World J. Adv. Eng. Technol. Sci.* **2024**, *13*, 1089–1104. [\[CrossRef\]](#)
86. Sarkodie, S.A.; Owusu, P.A.; Taden, J. Comprehensive green growth indicators across countries and territories. *Sci. Data* **2023**, *10*, 1–19. [\[CrossRef\]](#)
87. Kasztelan, A. Towards Green Growth: A Taxonomic Analysis Based on the Headline Indicators. *Eur. Res. Stud. J.* **2020**, *XXIII*, 879–894. [\[CrossRef\]](#)
88. Liu, X.; Wang, K.; Lu, H. Research on Supply Chain Decisions for Production Waste Recovery and Reuse Based on a Recycler Focus. *Sustainability* **2023**, *15*, 3320. [\[CrossRef\]](#)
89. Alrasheedi, M.; Mardani, A. Evaluating the green growth indicators to achieve sustainable development: A novel extended interval-valued intuitionistic fuzzy-combined compromise solution approach. *Sustain. Dev.* **2020**, *28*, 1521–1535. [\[CrossRef\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.