Responsible Governance in the Digital Age – Innovating for Sustainable Natural Resource Management

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Abstract— Digital transformation is fundamentally changing the approach to natural resource management in both the private and public sectors. In the context of increasing regulatory requirements and growing pressure on companies to integrate sustainable business models, digital technologies offer new opportunities for monitoring, optimization and transparency. At the same time, the public sector has an important role to play in stimulating sustainable practices through regulations, public policies and smart resource management. The mechanism of responsible governance in the context of digital and sustainable transformation is the object of the study and the aim is to analyze and evaluate how digitalization and sustainable management strategies can support effective natural resource management in the private and public sectors, focusing on the role of CSR. The objectives are: to investigate the main digital technologies and their application in natural resource management; to analyze the ESM strategies in enterprises and their impact on sustainable management; to assess the role of the public sector in supporting digital sustainable practices; to identify synergy between the public and private sectors for more effective natural resource management. The research thesis is that the successful combination of digital technologies and sustainable management practices leads to more effective and transparent natural resource management in both the corporate and public sectors, with CSR acting as a bridge between the two sectors. The results are expressed in: 1) digital technologies significantly improve natural resource monitoring, analysis and management. 2) ESG reporting and CSR are key enablers for integrating sustainable strategies into business, with management increasingly using automated platforms to assess environmental impacts. 3) the public sector plays an important role in promoting sustainable transformation through regulations, subsidies and smart infrastructure projects. 4) there are significant opportunities for synergy between business and the public sector through partnerships, data sharing and innovation in natural resource management.

Keywords— *responsible governance, sustainable natural resource management, digital and sustainable transformation.*

I. INTRODUCTION

In the digital age, the transformation of classical management models is not just an opportunity, but an urgent necessity. The adoption of sustainable management practices requires a systematic approach that integrates technological innovations with environmental implementations. The authors focus precisely on the aforementioned connection between digitalization and sustainability in the management of natural resources, emphasizing the possibilities of technological solutions and, more precisely, their ability to serve as a catalyst for change in both the private and public sectors. [1]-[2]

In turn, the management of natural resources is a major factor in the sustainable development of society and environmental protection. With the expansion of digital technologies, they are becoming an increasingly large and unavoidable factor that presents new opportunities for

monitoring, analysis, forecasts and optimization in the use and management of natural resources. Digital technologies are an effective tool when we talk about ESG (Environmental, Social, and Governance) criteria. ESG in themselves are the embodiment of people's aspiration for sustainability and social responsibility and serve as measures of these categories. To achieve environmental goals, improve social responsibility and engagement, and also to ensure transparency in management [3]. According to their functionality and application, digital technologies can be classified into the following five key categories, which have an important role in natural resource management (Table 1).

Regarding the management of natural resources and their management through digital tools, there are other criteria for their classification. Such criteria are the level of data processing, we distinguish between collection, processing, analysis and visualization; according to the degree of automation, we could distinguish those for automated management, decision-making and process control; according to the scope of application is another way of categorizing, for example.

TABLE 1 COMPARATIVE ANALYSIS OF DIGITAL TECHNOLOGIES

Technology	Application	*Advantages*	*Challenges*
Artificial intelligence and machine learning (AI & ML)	Pollution forecasting, resource optimization, data analysis	High accuracy of forecasts, ability to process large volumes of data	Need for large databases, complexity of algorithms
The Internet of Things (IoT)	Water, soil and air quality monitoring	Real-time data, early detection of problems	Limited energy efficiency, dependence on internet connectivity
Blockchain technology (BT)	Transparency in resource management, certification of sustainable practices	Transparency, security and immutability of data	High energy consumption for some protocols
Geographic Information Systems (GIS)	Resource mapping, ecological zone analysis and visualization	Spatial analysis, easy interpretation of data through maps	Dependence on up-to-date and accurate geographic data, need for specific skills and expensive software
Digital twins (DTs)	Ecological process simulations, human impact prediction	Possibility to test scenarios without real consequences	High complexity of creation and maintenance, requires significant computing resources

Source: Authors' own interpretation

The above classifications are also useful, but in the case of our study we use the classification that groups the technologies used according to their role in the management of natural resources, because in our opinion it reflects their relationship with ESG criteria. Grouped in this way, they reveal to us how each group of technologies contributes to achieving environmental, social and management goals. [4]

II.   MATERIALS AND METHODS

Through a multifaceted methodological and empirical approach, we have analysed some innovations in sustainable natural resource management, focusing on the interaction of digital technologies with the public and private sectors. The respondents of the study were selected from all 27 regional cities in Bulgaria, the number was reduced, given the administrative overlap between Sofia region and Sofia city.

The methodological framework is a combination of quantitative and qualitative methods, our goal is to achieve a comprehensive and objective analysis. As the main data collection tool, we used structured interviews conducted in the period July - November 2024, with representatives of the main stakeholders. The sample covered the main groups of the public sector (33.3%), business (33.3%), educational institutions (13.3%), citizens (6.7%) and non-governmental organizations (13.3%). We used a combined approach for greater representativeness and credibility. We selected experts from the public and business sectors through purposive sampling, and citizens through random selection, in accordance with the principles of stratified sampling.

To assess the application and effectiveness of the considered digital technologies in natural resource management, we used multi-criteria analysis (MCA), including: Analysis of variance (ANOVA) - to identify statistically significant differences between groups; Correlation analysis - to find relationships between digital technologies and key indicators of sustainable management; Multi-criteria decision-making method (MCDM): TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) - for a comparative assessment regarding the implementation of digital technologies. The study also applied Content Analysis to enrich the quantitative methods and allows identifying key themes, patterns and attitudes. [5]

The collected data covers both quantitative assessments and qualitative responses of the respondents. The participants in the study assessed various indicators related to digital transformation and sustainable management on a ten-point scale, where 1 means "poor performance" and 10 – "excellent performance". Additionally, the participants had the opportunity to make free comments, which we use to enrich the analysis.

We combined the mentioned methods and thus realize our aspiration for a deeper and more detailed disclosure of the problems addressed in the study. Integration and consideration of the problem in its entirety allowed us to conduct this complex analysis of the impact of digital

technologies on the management of natural resources. Such a detailed consideration of the connections and dependencies is a stable basis for formulating recommendations for strategic decisions and implementing sustainable practices.

III. RESULTS AND DISCUSSION

A. *Key digital technologies and their application in natural resource management.*

The ESG criteria, as the abbreviation indicates and has already been mentioned, cover the following three areas: Environment, Social and Governance. Through structured interviews, we obtained the weights determined by the experts (environmental impact – 40%, corporate governance – 28%, social effects – 32%) and expert assessments. The initial data, as well as the corresponding calculations from the multi-criteria analysis (MCA) (1) are presented in Table 2. We use the MCA analysis to get an initial idea of the different alternatives. At this stage, favorites and technologies that do not correspond in the best way with ESG stand out from the calculations. [6]

$$P = E \times \omega_E + S \times \omega_S + G \times \omega_G \quad (1)$$

Where:

P – Weighted Score

E: Environmental Impact Score

S: Social Impact Score

G: Corporate Governance Score

ω_E Weight for Environmental Impact (40%)

ω_S Weight for Social Effects (32%)

ω_G Weight for Corporate Governance (28%)

TABLE 2 MCA

Technology	E (1-10)	S (1-10)	G (1-10)	Average score	P
AI & ML	7,25	7,25	8,25	7,58	7,53
IoT	8,00	6,75	7,00	7,25	7,32
BT	5,50	5,75	8,50	6,58	6,42
GIS	8,25	7,50	7,00	7,58	7,66
DTs	7,25	6,50	7,50	7,08	7,08

Source: authors' own research

We continued with the analysis of variance (ANOVA) in detail. We defined two hypotheses, working with a null and an alternative.

H_0 Null hypothesis according to which we will not find large differences between the average ratings of technologies in terms of ESG.

H_1 Alternative hypothesis according to which the analysis will find significant differences between the average ratings of technologies in terms of ESG.

Then we moved on to calculating the overall average value (2)

$$\tilde{X} = \frac{Sum \ of \ all \ ratings}{Total \ number \ of \ ratings} \quad (2)$$

$$\tilde{X} = \frac{93,7}{15} = 6,25$$

To determine the deviations of the average values of the (groups of) technologies from the overall average, we calculate the intergroup variance SSB (3) and the intragroup variance SSW (4) which reveals the differences in individual estimates. [7]

$$SSB = \sum_{i=1}^{k} n_i (\breve{X}_i - \breve{X})^2 \quad (3)$$

$$SSW = \sum_{i=1}^{k} \sum_{j=1}^{n_i} (X_{ij} - \breve{X}_i)^2 \quad (4)$$

With the available data, we obtain for SSB = 16.02 and SSW = 7.81. We calculate the F-statistic (5) and compare it with the critical value at a given significance level of 0.05. The calculations show an F value of 5.13 and a critical value of 3.48

Because F = 5.13 > 3.48, we should reject the null hypothesis. We could argue from the results obtained in this way that the ESG criteria have large differences between the average ratings of the technologies. That is, the differences are not random and deserve to be examined in more detail. For this purpose, we apply TOPSIS analysis, going through the standard stages of matrix normalization, calculation of an ideal and antagonistic solution, followed by calculation of the distances between each row, finding the relative proximity to the ideal solution Ci and ranking. By going through the described steps, we obtain a relevant proximity to the ideal state, and through the values we perform the ranking (Table 3).

According to TOPSIS analysis, the most suitable technology in terms of ESG is GIS. This is the technology closest to the ideal solution. As can be seen from Table 3, BT technologies are not recommended at this stage.

B. *Analyzing ESG strategies in enterprises and their impact on sustainable management*

With increasing pressure from regulators, investors and society, businesses are increasingly integrating ESG (Environmental, Social, and Governance) strategies as a key tool for sustainable management.

TABLE 3 RANKING

Technology	C_i	Ranking
AI & ML	0,644	2
IoT	0,597	3
BT	0,522	5
GIS	1,000	1
DTs	0,584	4

Source: authors' own research

The key question facing businesses is how to transform their operations to combine economic efficiency, environmental responsibility and social sustainability. In this context, a needs analysis of ESG strategies in enterprises will be carried out. To successfully implement ESG strategies, enterprises need to address several key aspects:

a) Environmental dimension (E - Environmental), including: optimizing the use of natural resources through digital technologies (IoT, Big Data, AI); reducing carbon footprint and implementing circular economy; regulatory compliance (CSRD, ESRS).

b) Social dimension (S - Social), as follows: increasing employee engagement through ethical business practices; investing in training and enhancing digital skills of staff; adopting socially responsible policies - safe working conditions, diversity and equity.

c) Corporate governance (G - Governance), including: integration of ESG criteria in strategic management; transparency and accountability in decision-making; application of digital tools for monitoring and reporting (blockchain, AI-based reporting).

For the purpose of the study, we apply an analytical tool that represents how environmental (Environmental), social (Social) and governance (Governance) aspects intertwine and influence sustainable management in enterprises, namely the ESG matrix (Table 4). It will be visualized as a table with three main dimensions (E, S, G) along the horizontal and key impact areas along the vertical. The aim is that each cell will show how a particular ESG factor impacts the business.

This matrix is extremely useful for companies in the process of: 1/ strategic planning to identify important ESG priorities; 2/ assessing impact by analyzing the effects of sustainable business policies; 3/ ensuring reporting and transparency by demonstrating the ESG approach to stakeholders.

Next, the research focuses on the analysis of the relationship "ESG Strategies" – "Economics and Environmental and Nature Management" – "Profit and/or added value for enterprises".

TABLE 4 ESG MATRIX (INTERACTION BETWEEN ENVIRONMENTAL, SOCIAL AND GOVERNANCE FACTORS)

Area of impact	Environmental (ecology)	Social (social responsibility)	Governance
Resource management	Water optimization, energy efficiency, circular economy.	Workplace safety, working conditions, health.	Monitoring through ESG indicators, digital tracking systems.
Regulations and compliance	Compliance with environmental standards (CSRD, ESRS, Paris Agreement).	Compliance with ethical labor standards, equality and non-discrimination.	Transparency in governance, anti-corruption practices.
Innovation and digitalization	Implement IoT, AI, Big Data to reduce environmental footprint.	Social innovation – training, qualification.	Using blockchain and AI for reporting and control.
Financial management	Investment in green technologies and sustainable business models.	Engaging employees and customers through social projects.	ESG reporting for investors and stakeholders.
Reputation and brand	Positioning as a green business – competitive advantage.	Social responsibility as a factor for attracting customers.	Good governance increases investor confidence.

Source: Authors' own interpretation

Implementing ESG strategies in enterprises is a long-term business strategy that impacts both the financial performance and the added value of the enterprise. It can be argued that a complex relationship between ESG principles, natural resource management and the economic performance of enterprises is emerging, existing and evolving. This relationship will be examined in the context of the present work as follows:

a) The link between ESG factors and natural resource management strategies will be explored to determine how sustainability principles influence responsible environmental practices. *First*, environmental aspect (E). The focus is on optimization, energy sources, green financing. Resource optimization through energy efficiency, circular economy and low carbon technologies reduces operational costs. Reducing the carbon footprint and using green energy sources attracts sustainable investors. A focus on ESG can provide access to green financing and subsidies. *Second*, social aspect (S), which focuses on working conditions and social responsibility. Improving working conditions, employee health and safety increases productivity. ESG-focused businesses attract more engaged customers and investors who value social responsibility. *Third*, Governance aspect (G), which primarily relates to corporate governance. Good corporate

governance ensures transparency, reporting and effective management. At the same time, the integration of digital ESG monitoring solutions increases efficiency and reduces the risk of regulatory sanctions.

b) The interaction between ESG considerations and financial outcomes – whether in the form of costs or investments – will be analyzed to assess their impact on corporate performance. ESG strategies are often seen as an additional cost to the enterprise, but in realities they can be applied as a tool to create competitive advantage and long-term profitability. ESG increases the profitability of companies by: 1/ reducing operating costs through energy efficiency and circular economy. 2/ increasing market value as sustainable companies are preferred by investors. 3/ improving reputation and customer loyalty - today there is a growing trend for consumers to seek environmentally and socially responsible brands. [8] 4/ access to green financing and subsidies.   According to reports by international financial institutions, companies with high ESG ratings have lower capital risk and higher long-term profitability.

c) The concept of added value, including activities that extend beyond profit-making, will be discussed in order to highlight the broader societal and environmental contributions of business entities. While the traditional business model measures success mainly through the financial result, the ESG approach creates multi-layered added value, which translates into economic added value (cost optimization, innovation in sustainable production); social added value (better conditions for employees, building trust in society); environmental added value (better management of resources and reduced environmental footprint). ESG-related strategies are an inevitable factor in modern management as they ensure not only regulatory compliance but also sustainable competitive advantage. The balance between economic performance and natural resource management is key to the long-term sustainability of both businesses and society as a whole. The balance between ESG policies, business profit and added value depends on the specific business model, industry and strategic priorities of the enterprise. Our study, based on the monitoring of a set of criteria in business activity, divided enterprises into three profiles. Profit-minded enterprises focus on profit (60%), with less emphasis on ESG. Eco-minded Enterprises are distinguished by ESG being the top priority (50%), with business profit being in the background. Open-minded Enterprises have a balanced approach between the three factors. If the enterprise is profit-driven, the focus will be on profit maximization, and ESG will play a role mainly in the extent to which it is necessary to regulate or improve reputation (fig. 1). When a company is eco-minded, it is more likely to place a greater emphasis on ESG policies, even at the expense of some short-term profit, but with the goal of long-term sustainability and reputational benefits (fig. 2). Open-minded enterprises (innovative and large companies) can seek an optimal balance by integrating sustainable practices that both bring profit and create long-term added value. Pursuing a balanced approach between

the three factors as it shown in fig. 3. The three graphs visualize the allocation of ESG policies, business profit and value added for different types of businesses.
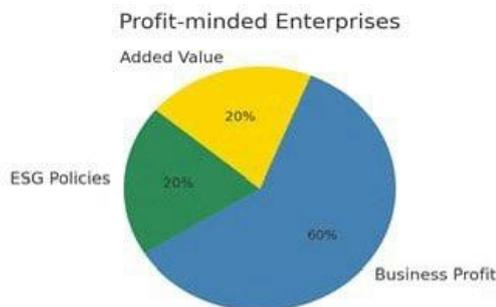

Fig. 1.   ESG strategies via Profit-minded enterprises.
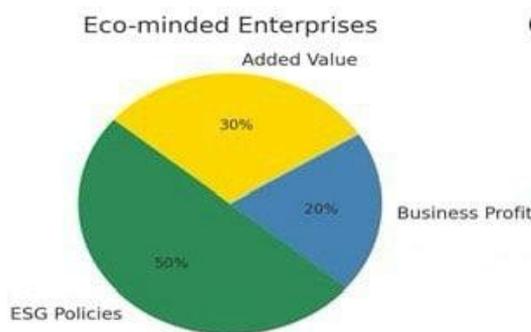
Source: Authors' own research.

Fig. 2.   ESG strategies via Eco-minded enterprises.
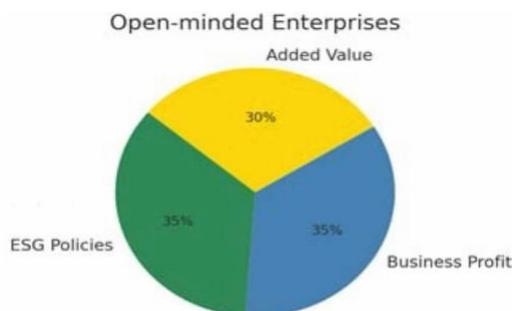
Source: Authors' own research.

Fig. 3.   ESG strategies via Open-minded enterprises.

Source: Authors' own research.

Next, an ESG Value Chain (fig. 4) will be created to illustrate how sustainable practices need to be transformed into competitive advantages. The graphic will include: 1/ ESG initiatives (sustainable raw materials, carbon footprint

reduction, social responsibility, management transparency). 2/ Internal processes (resource efficiency, automation, employee engagement). 3/ Business performance (reduced costs, access to green finance, increased reputation). 4/ Competitive advantages (increased customer loyalty, sustainable supply chains, regulatory relief).

C. Role of the public sector in supporting digitally sustainable practices

The public sector has a significant impact on sustainable practices through some basic instruments such as policies in various directions, regulations at different levels and a number of initiatives (Fig. 5). In addition to the main ones indicated in Fig. 5, which are mainly directed "outward", that is, impacts and efforts towards entities outside its functions. The public sector needs to initiate and implement activities directed "inward", concerning the internal functioning of the sector. Such could be incentives for the use of energy-efficient devices, reducing paper consumption, reducing, and other sustainable practices. In the context of ESG, we can also note the exceptional importance of the sector in the management of e-waste. For example, by building recycling systems and tracking them in real time and electronically. Another area of great importance for public decisions is the development of digital infrastructure, which will allow not only the administration itself, but also citizens and businesses to use digital services more intensively and regularly. [9]-[11]

Fig. 4.   ESG Value Chain.

Source: Authors' own interpretation

Fig. 5.   Magnetization as a function of applied field.

Source: Authors' own interpretation

D. Synergy between the public and private sectors for more effective natural resource management

Public-private synergies in the context of more efficient natural resource management. [12] These synergies can be realized through various mechanisms, such as policy collaboration, innovation and digitalization, knowledge and resource sharing and joint initiatives, as follows:

a) Joint policy development. The private sector can provide expertise and innovation, while the public sector provides the regulatory framework and incentives for sustainable governance. A good example is partnerships to create national and international standards for sustainable use of natural resources.

National and international partnerships for setting standards in the sustainable use of natural resources play a key role in ensuring efficient and fair resource management, which is essential for sustainable development. These collaborations between the public sector (governments, regulators) and the private sector (companies, business associations) support the co-creation and implementation of standards that promote good practices, regulatory compliance and sustainability goals. By combining public leadership in establishing legal frameworks with private sector innovation and technical expertise, such partnerships enable the development of shared goals, certification schemes and mechanisms for integrating advanced technologies like digital monitoring tools and AI-based forecasting. They also foster the exchange of good practices across sectors and countries and facilitate joint efforts in monitoring and reporting. Initiatives like the Forest Stewardship Council (FSC), the Global Reporting Initiative (GRI) and platforms such as the Sustainable Agriculture Initiative exemplify the potential of coordinated action in driving sustainable resource use globally.
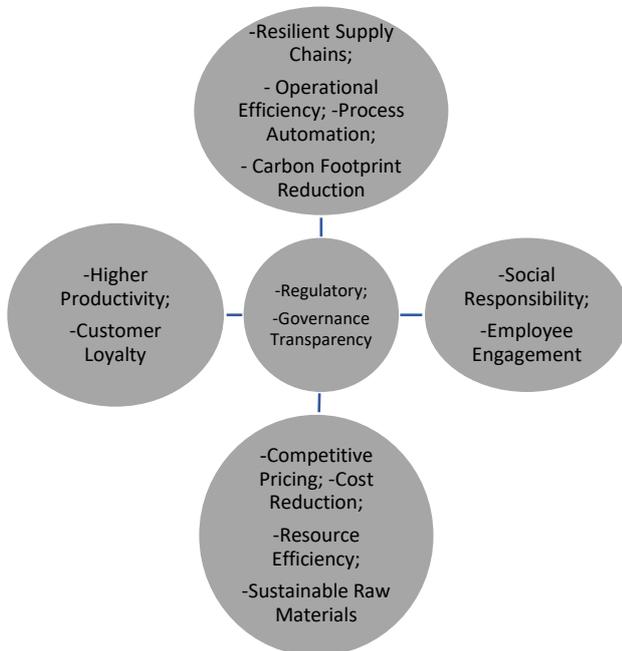
In the context of partnerships aimed at establishing national and international standards for the sustainable use of natural resources, it is essential to draw on global initiatives and proven best practices. International frameworks such as the United Nations Environment Program (UNEP), the Paris Agreement and the Convention on Biological Diversity (CBD) offer valuable guidance and platforms for cooperation between governments, the private sector and civil society. [13]-[15] These initiatives not only coordinate efforts for sustainable natural resource management but also encourage countries to adapt global standards to local conditions through innovation and collaboration. By facilitating the alignment of environmental goals with technological advancement and inclusive governance, such partnerships contribute significantly to achieving the global sustainability agenda, while also promoting economic efficiency and social well-being.

b) Investing in green technologies. Cooperation may involve funding green technology innovations aimed at reducing carbon emissions and improving resource efficiency, as demonstrated by public-private partnerships in renewable energy and sustainable agriculture. [16]

Investing in green technologies is one of the main drivers of sustainable development and a key factor in reducing carbon emissions and increasing resource efficiency. Through public-private cooperation, such innovation can be supported to deliver significant benefits for the conservation of natural resources and the reduction of negative environmental impacts. This type of partnership may encompass financing, technological advancement, collaborative research and the promotion of innovative business models.

Green energy solutions, including solar, wind and geothermal technologies, represent a central area of investment. Both the public and private sectors play an important role in financing and deploying renewable energy systems aimed at reducing dependency on coal and nuclear sources. Examples include investments in solar panels and wind farms, with good practices being public-private partnerships that develop such infrastructure in regions with high renewable energy potential. Energy efficiency is another significant domain, involving technologies that minimize energy consumption across industrial processes, transport, buildings and infrastructure. Notable examples include innovations in building insulation materials and the development of smart grids that optimize energy distribution and usage. Cleaner production technologies are also a focus of investment, particularly those that reduce carbon emissions in industrial operations. These include carbon capture and storage (CCS) processes as well as technologies for recycling and waste recovery. Financing programs aimed at supporting green industrial solutions that minimize waste and pollution are considered best practices in this context. Sustainable transport innovations such as electric vehicles (EVs), hybrid systems and alternative fuels like hydrogen-based engines are likewise essential. Public-private partnerships to develop charging infrastructure, as well as

support for autonomous mobility and shared transportation platforms, contribute to the greening of the transport sector. Furthermore, the circular economy approach encourages investments in technologies for reuse, recycling and resource recovery. This reduces waste generation and maximizes material efficiency. Good practices in this area include investments in recycling technologies for plastics, glass and metals, which support the emergence of new business models focused on the reuse of products and materials. [17]

This raises the question of the role of the public and private sectors in investing in green technologies. The public sector contributes through funding mechanisms such as subsidies, tax incentives and regulatory frameworks that make green technologies economically viable. The European Union, for example, supports innovation through programs like Horizon Europe. The private sector, especially start-ups and tech companies, plays a leading role in developing renewable energy solutions, energy efficiency technologies and green innovations, often collaborating with universities and other industries. Collaborative research platforms between academia and business are fundamental for advancing technologies such as carbon sequestration or efficient renewables. Industry associations and initiatives like the Green Tech Festival and Circular Economy 100 further promote joint solutions and standards for sustainable development. [18]

c) Collaborative implementation and resource optimization. Public-private synergies in natural resource management create the conditions for long-term sustainability, innovation and economic efficiency. Through shared knowledge and data, public authorities can provide valuable environmental and climate information, while private actors use it to develop effective solutions for resource optimization, such as in water management. These synergies are further strengthened through joint initiatives for ecosystem restoration and sustainable land, forest and water use, as well as through co-financing of infrastructure projects that support energy efficiency, circular economy practices and responsible resource use. Such integrated efforts foster not only environmental stewardship but also economic resilience, making them a major driver for sustainable development.

An essential aspect of this cooperation is the establishment of common platforms for data sharing and analysis, where environmental trends can be monitored and addressed collectively. Co-investment in resilient infrastructure, such as smart irrigation systems or decentralized energy networks, demonstrates how both sectors can align efforts for greater impact. Pilot projects and demonstrators, jointly initiated by governments and businesses, can test new models for sustainable management before broader application. In addition, cross-sectoral partnerships enable the scaling of good practices and the replication of successful initiatives in different regions. Ultimately, these collaborative actions strengthen institutional capacity and promote a culture of joint responsibility in managing natural resources sustainably.

IV. CONCLUSIONS

The study showed how digitalization with its tools, strategies and policies can improve the management of natural resources in both the business and public sectors. The following statements were made:

First. Digital technologies contribute to better management of natural resources. Through their use and improvement, natural resource management will be transformed to new levels. Technologies such as remote sensing, AI-based analysis and IoT systems enable more precise monitoring, predictive planning and responsive interventions. Their integration leads to more efficient, transparent and adaptive systems that minimize resource waste and environmental harm.

Second. ESG initiatives and their monitoring are vital for the long-term implementation of sustainable practices, both by business and the public sector. Their integration into corporate and institutional strategies ensures accountability, drives innovation and aligns operational goals with environmental and social responsibility. Digital tools support the traceability and verification of ESG commitments, fostering trust and comparability across sectors.

Third. Maximum results would only be achieved through synergy and partnership between all stakeholders. A shared vision and coordinated action among governments, private companies, civil society and academia are key to scaling good practices and ensuring the sustainability of natural systems. The combined efforts of these actors enhance knowledge exchange, align investments and create the conditions for systemic change.

REFERENCES

[1] C. Nwani, E. L. Effiong, K. Ikechukwu Okere, and P. T. Iorember, "Beyond the barrels: The impact of resource wealth on the energy-economy-climate targets in oil-rich economies," Heliyon, vol. 10, no. 3, art. no. e25666, 2024. doi: 10.1016/j.heliyon.2024.e25666.

[2] H. H. Trinh, M. McCord, D. Lo, and G. Squires, "Do green growth and technological innovation matter to infrastructure investments in the era of climate change? Global evidence," Appl. Econ., vol. 55, no. 35, pp. 4108–4129, 2023. doi: 10.1080/00036846.2022.2125493.

[3] M. M. Kabir et al., "Machine learning-based prediction and optimization of green hydrogen production technologies from water industries for a circular economy," Desalination, vol. 567, art. no. 116992, 2023. doi: 10.1016/j.desal.2023.116992.

[4] E. Yontar, "Critical success factor analysis of blockchain technology in agri-food supply chain management: A circular economy perspective," J. Environ. Manage., vol. 330, art. no. 117173, 2023. doi: 10.1016/j.jenvman.2022.117173.

[5] S. Y. Barykin, I. V. Kapustina, S. M. Sergeev, and V. K. Yadykin, "Algorithmic foundations of economic and mathematical modeling of network logistics processes," J. Open Innov.: Technol., Market, Complex., vol. 6, no. 4, art. no. 189, pp. 1–16, 2020. doi: 10.3390/joitmc6040189.

[6] E. Uche, N. Das, and P. Bera, "Re-examining the environmental Kuznets curve (EKC) for India via the multiple threshold NARDL procedure," Environ. Sci. Pollut. Res., vol. 30, no. 5, pp. 11913–11925, 2023. doi: 10.1007/s11356-022-22912-1.

[7] Ş. Yılmaz Balaman, D. G. Wright, J. Scott, and A. Matopoulos, "Network design and technology management for waste to energy production: An integrated optimization framework under the principles of circular economy," Energy, vol. 143, pp. 911–933, 2018. doi: 10.1016/j.energy.2017.11.058.

[8] I. Kulova and V. Alexieva, "ESG strategy: Pivotal in cultivating stakeholder trust and ensuring customer loyalty," in E3S Web of Conf., vol. 462, Dec. 2023. doi: 10.1051/e3sconf/202346203035.

[9] D. Hemanand et al., "Applications of intelligent model to analyze the green finance for environmental development in the context of artificial intelligence," Comput. Intell. Neurosci., vol. 2022, art. no. 2977824, 2022. doi: 10.1155/2022/2977824.

[10] J. Li, G. Zhang, J. P. Ned, and L. Sui, "How does digital finance affect green technology innovation in the polluting industry? Based on the serial two-mediator model of financing constraints and research and development (R&D) investments," Environ. Sci. Pollut. Res., vol. 30, no. 29, pp. 74141–74152, 2023. doi: 10.1007/s11356-023-27593-y.

[11] A. Ganchev, "The performance of hedge fund industry during the COVID-19 crisis – theoretical characteristics and empirical aspects," Economic Studies (Ikonomicheski Izsledvania), vol. 31, no. 1, pp. 18–37, 2022.

[12] I. Tarasenko, V. Kruhlov, T. Stepanenko, and G. Moroz, "Public-private partnerships in natural resource management as a basis for the implementation of the ecological and economic security doctrine of Ukraine's development," Int. J. Prof. Bus. Rev., vol. 8, no. 6, p. e02315, Jun. 2023.

[13] B. Desai, "14. United Nations Environment Programme (UNEP)," in Yearb. Int. Environ. Law, vol. 32, no. 1, Sep. 2022.

[14] S. Matemilola, O. Fadeyi, and T. Sijuade, "Paris Agreement," in Encyclopedia of Sustainable Management, SpringerLink, Sep. 2020. doi: 10.1007/978-3-030-02006-4_516-1.

[15] Convention on Biological Diversity. Text and Annexes, 2011. [Online]. Available: https://www.cbd.int/doc/legal/cbd-en.pdf.

[16] P. Kumar, "An overview on green technology," J. Gujarat Res. Soc., vol. 22, no. 1, pp. 1341–1347, Jan. 2020.

[17] Z. Xian, "Research on green technology innovation model and system improvement based on environmental protection," in IOP Conf. Ser.: Earth Environ. Sci., vol. 94, no. 1, 2017. doi: 10.1088/1755-1315/94/1/012115.

[18] G. Soni, "Advantages of green technology," Int. J. Res. - GRANTHAALAYAH, vol. 3, no. 9SE, pp. 1–5, 2015. doi: 10.29121/granthaalayah.v3.i9se.2015.3121.

[19] B. Liu, J. Li, D. Wang, and H. Liu, "Public–private partnerships: A collaborative framework for ensuring project sustainable operations," Eng., Constr. Archit. Manage., vol. 31, no. 1, Sep. 2022.