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The Role of Artificial Intelligence in Natural Resource Management: Issues of Transparency and Efficiency

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Abstract

Natural resources can generate significant wealth for a country by supporting livelihoods, food security, and the green economy, as well as producing trade and entrepreneurship at the local, national, and global levels. However, due to the massive amounts of revenue at stake, the extractives sector is frequently associated with weak governance and corruption. One of the core paradigms constituting the research is resource rent. The high rents created by natural resource earnings encourage rent-seeking, corruption, and favoritism, which can lead to poor and inequitable investment and spending practices. The article represents an attempt to trace patterns of dependencies between natural resources, sustainable use factors within the domain of social welfare, and national financial security. Based on thematic analysis and employing cases, the study suggests implementing AI in public administration to reduce shadowing and inefficient use of resources. In particular, the case of AI usage to combat deforestation is analyzed. Particular emphasis is also made on stakeholders' interests and decentralized arrangements of natural resource governance. It was revealed that the power relationships among stakeholders may have a big influence on how well governance frameworks for managing natural resources work.

Keywords

Natural resources use; Sustainability, AI solutions; Efficient management; Policy; National financial security

Introduction

Current public discourse increasingly reflects the notion that artificial intelligence is revolutionizing natural resource management by

providing tools that enhance accessibility, reduce costs, optimize data utilization, and improve efficiency. AI-powered solutions are being used in a variety of fields, including smart grids, biodiversity protection, animal monitoring, and sustainable urban development. However, a range of issues is often omitted, which leads to superficial vision and a lack of systematic approach and depth in the comprehension of the role of artificial intelligence in natural resource management - in particular, the context of National Financial Security, predominantly is not significantly taken into consideration.

Since natural resources are limited, effective management is necessary to meet long-term objectives. According to Shah *et al*. (2023), effective management of natural resources is necessary to ensure that present generations may meet their demands while protecting them for future generations. This becomes even more challenging in the age of climate change concerns. Environmental sustainability is hampered by social inequality, resource exploitation, and growing urbanization (Geng, Rao and Sharif, 2022). Therefore, in light of the 2030 Agenda, economic, social, and environmental aspects should all be incorporated into sustainable development. Policies and initiatives based on social justice, ecological sustainability, economic efficiency, and resilience should be used to achieve this integration (Puntillo, 2023; Roy *et al*., 2023).

While sustainability must be prioritized, governments should also protect biodiversity and limit the loss of natural resources. As the globe works to adapt to climate change, this is particularly crucial since governments will need to adopt a coordinated strategy to address social and economic disparities and guarantee financial stability. It is becoming increasingly more crucial for governments to use cutting-edge technology like artificial intelligence, machine learning, and big data analytics in order to successfully address the problems caused by climate change, while accomplishing sustainability goals. Large volumes of data concerning the environment, natural resources, and social issues can be analyzed with the use of these tools, which can then become a foundation for policy decisions that support sustainable economic growth and conservation. According to research, these algorithms can help to establish methods for adapting to climate change, encourage the efficient use of energy, and improve resource utilization (Pandey *et al*., 2023).

Artificial intelligence is transforming natural resource management by increasing efficiency, accuracy, and sustainability in a variety of industries, including forestry, agriculture, and wildlife protection. AI algorithms, particularly machine learning, are used to automate data analysis, make better decisions, and allocate resources more efficiently. Forest management is one area where artificial intelligence can be extremely useful. For example, a business called NCX employed AI to map every acre of forest in the continental United States. Having an accurate inventory allows landowners and foresters to determine which trees to chop and which to leave standing. AI tools also assist forest managers in conducting “controlled burns” to eliminate excess brush that could ignite wildfires. They can use artificial intelligence to predict when the weather is optimum for starting a fire without jeopardizing neighboring communities (Bashtannyk, Terkhanov and Kravtsov, 2024; Ortina, Zayats and Karpa, 2023; Zilinska, Avedyan and Kyrychenko, 2022).

AI technologies have evolved into a strategic approach to addressing challenges in mining, precision agriculture, wildlife conservation, forest monitoring, water resource management, and community-based natural resource management (CBNRM). According to Molossi and Pipan (2023), in mineral exploration, AI algorithms analyze geological and geophysical data to discover probable mineral resources, which allows saving time and financial resources. AI-based models in water resource management assess groundwater availability, monitor water quality, and predict threats like droughts and floods, allowing for more informed conservation and sustainable management decisions (Gxokwe *et al.*, 2022; Sumets et al., 2022; Umer *et al*., 2022). AI-driven systems monitor biodiversity, illicit logging, and changes in forest cover. AI-driven technologies are used in wildlife conservation to track animal movements, stop poaching, and lessen conflicts between people and wildlife. Additionally, through data-driven recommendations, AI systems optimize crop output, boost agricultural pest management, and improve soil fertility. These developments highlight AI's revolutionary potential across a range of natural resource management domains.

Cases within the African context are of particular interest, since here the quality of institutions usually plays quite an evident role, often a detrimental one. The recent finding of massive copper deposits in Zambia (Mitimingi and Hill, 2024), the use of AI-powered drones for wildlife monitoring and antipoaching operations in Burkina Faso (Kapatamoyo, 2024), and precision agricultural methods are some notable instances, particularly in Africa. Furthermore, through CBNRM programs, AI analytics are used in water resource management methods to forecast and control water quality and availability while empowering local populations. These case studies demonstrate the various ways artificial intelligence is being used in Africa, highlighting how it can improve conservation efforts, decision-making, and the sustainable management of natural resources throughout the continent.

In summary, artificial intelligence significantly enhances governmental management of natural resources by promoting sustainability, accuracy, and efficiency across sectors such as waste, energy, and water. AI can foresee demands, optimize resource allocation, and cut waste by analyzing data and automating tasks. This results in cost savings and better environmental consequences. Green technology is required to lessen and even reverse the environmental problems that humanity will confront in the ensuing decades. To manage natural resources sustainably, governments are taking action to put in place more intelligent data analytics platforms. Some core applications of AI in natural resources management are summarized in table 1.

It should be noted that good natural resource management (NRM) is critical for national financial security because it provides long-term access to important resources while reducing the risks associated with resource depletion or mismanagement. Sound NRM practices help to maintain economic stability, avoid resource conflicts, and promote long-term prosperity (Chaliuk *et al*., 2021). NRM and national finance are inextricably linked, especially in countries that rely heavily on natural resources. Effective natural resource management necessitates rigorous financial management to assure long-term resource exploitation, income production, and equitable benefit distribution. In contrast, strong national financial policies are critical for promoting sustainable NRM practices and minimizing the potential negative economic effects of resource extraction.

Table 1. Applications of AI in the natural resource management (Arivazhagan *et al*., 2023; Avedyan and Belyavtseva, 2023; Nawale and Ralegaonkar, 2025; Voronina, Lopushynskyi and Grechanyk, 2024)

Application	*Details and benefits*
Mapping the Biomass Inventory	Decisions about resource management and sustainability policies and efforts can be informed by the use of machine vision to analyze satellite photos and track the quality and utilization of natural resources. *Benefits:* - Efficient resource management - Making wiser choices that result in more sustainability
Forecasting of Emissions	Predictive analytics and data from distant sensors can be used to identify farmland regions that will produce the highest greenhouse gas emissions, allowing for the modification of laws, incentives, or cooperative efforts. *Benefits:* - More efficient laws governing emissions - Quicker reaction times - Reduced emissions of CO_2
Systems of Early Warning	ML can assess high-risk areas, forecast the movement and spread of hazardous events like fires, and assist in directing controlled cut and burn-back to stop fires from spreading. *Benefits:* - Early warning systems - Reduced harm to resources
AI-Assisted Forestry and Agriculture	Machine learning can be used to find suitable planting sites, monitor plant health, identify weeds, and evaluate patterns in order to enable smarter and more efficient agriculture. *Benefits:* - Better harvests - Improved quality of food

Recent research further links natural resource management to green finance, with studies showing that both resource rents and education positively influence green finance development in emerging economies (Liang and Yang, 2024). This underscores the importance of integrating AI-enabled resource governance with financial strategies that advance sustainability and public welfare. At the same time, a core emphasis is usually made on technical aspects of AI's potential efficiency in natural resources management, while the issues of transparency are not properly considered. Within this evolving landscape, the present study examines how AI can enhance transparency, efficiency, and accountability in natural resource management, with a particular focus on its implications for national financial security. By situating AI within systemic approaches to governance, this research aims to contribute to the scholarly discourse on sustainable resource utilization in an era of environmental and economic uncertainty.

Methodology

Data Sources and Search Strategy

This study employed a qualitative approach using thematic analysis based on predetermined themes formulated during the preparatory stage of research. Relevant publications that met a predetermined inclusion criterion were collected from scholarly indexes such as Wiley, ScienceDirect, MDPI, JSTOR, and ResearchGate, as well as through Google search. The manual search predominantly focused on topics and abstracts using keywords like "AI in natural resource management," "good natural resource management," "AI component in national financial security," and "governance issues in natural resource management." Additionally, peer-reviewed publications were retrieved from the mentioned scholarly databases, supplemented by Google searches that combined Boolean operators (e.g., AND, OR) with core keywords including "natural resource governance," "resource management policies," "sustainable natural resource management," "AI in managing natural resources," and "natural resource management and financial security."

Inclusion Criteria

Studies were included if they examined effective or ineffective natural resource management practices, integrated a sustainability perspective, identified governance-related barriers to achieving environmental objectives, demonstrated methodological transparency, and minimized political or ideological bias (particularly in contexts where bias is more likely, such as politically sensitive regions), considered the use of digital technologies, especially AI, in natural resource management, and were published in English.

Exclusion Criteria

Publications were excluded if they lacked methodological clarity, were purely opinion-based without empirical evidence, or were non-English sources.

Data Analysis

The selected studies were analyzed using thematic analysis. Themes were developed inductively from the literature and cross-checked against the research objectives. Recurring concepts related to governance challenges, sustainability practices, and AI applications were identified and categorized to facilitate synthesis.

Results and Discussion

Natural resources and economic growth

Natural resources are seen as a significant tool for economic development and a contentious issue among academics. Furthermore, a previous study has shown that the abuse and exploitation of natural resources have caused severe environmental damage. Natural resources are critical to the growth and development of any economy. They are

the fundamental building elements for a variety of businesses, including agriculture, construction, energy generation, and manufacturing. The use of these resources contributes to economic growth by creating jobs and money, eventually determining the level of national financial security. However, ineffective exploitation of natural resources led to a tremendous environmental impact. The extraction, processing, and exploitation of these resources frequently involve the use of hazardous chemicals, heavy machinery, and deforestation, which can have a negative impact on the ecosystems and biodiversity (Yorkina *et al*., 2021). The loss of natural resources can have far-reaching implications, endangering many facets of national security.

A case of deforestation: financial effects

Specifically, there are unspoken detrimental financial effects of deforestation (Almeida, Lagoa and Vasudhevan, 2024). The Aichi objective, which aims to reduce the pace of forest loss by at least half by 2020, is one of several global biodiversity conservation goals that have been in place for decades. But generally speaking, they have not been met, raising questions about how well quantitative target-setting works to bring about revolutionary change in land-use administration. Deforestation is also exacerbated by pressures from domestic governance.

For controlling land-use change, nations frequently have complicated, unclear, and dispersed legislative frameworks that prioritize economic expansion above conservation and are primarily influenced by the demand for resources around the world. This makes deforestation possible, especially when governments give concessions for the development of infrastructure or agriculture in wooded areas. Political issues that negatively affect local communities and Indigenous groups, such as weak tenure rights, a lack of transparency in the management of forest resources, poor enforcement of regulations, and "elite capture", in which the benefits of resources are retained by a small number of powerful actors rather than shared with the general public, further exacerbate pressures on forests.

The well-documented decline of forest ecosystems in recent decades has had a substantial impact on economic and financial systems due to the loss of ecosystem services. These effects are felt by households, businesses, financial institutions, and the macroeconomy as a whole through physical risks and "transition risks", which are associated with the process of moving toward a more sustainable economy. Businesses that are very vulnerable to hazards associated with deforestation not only help to sustain these cycles but also directly suffer from them. Lower productivity, increased production costs, and a decline in market competitiveness are the results. Such effects on financial institutions could result in asset devaluation, higher default rates, and a lack of liquid assets, which would raise systemic risk and necessitate paying more attention to how environmental criteria are incorporated into risk analysis and management procedures (Ferdman *et al*., 2025; Mia *et al*., 2022; Petrukha *et al*., 2025; Sydorchuk, Kharechko and Khomenko, 2024).

Cattle ranching is the primary cause of deforestation worldwide, and it is a key component of this equation. About 60% of the world's deforestation caused by land conversion to pasture occurs in Brazil alone (Carvalho, 2025). One of the industries in

Brazil that presents the biggest financial risks to organizations that have direct or indirect involvement in this supply chain is the raising of cattle.

Addressing this reality necessitates more than mere adaptation; it requires recognition of the financial sector's active role in the dynamics of deforestation. These hazards are both endogenous and external to the financial system, exhibiting dual materiality: financial institutions have the power to either promote or prevent deforestation through their financing and investment activities. In a global setting where environmental concerns are becoming increasingly more important, this is not only about reducing short-term risks but also about enhancing portfolio resilience and promoting long-term financial stability.

Addressing deforestation is especially important for investors looking to match their climate commitments with zero-emission portfolios in Brazil, where land-use conversion, animal farming, and agriculture account for over 75% of national emissions. Even if certain leaders in the financial sector have made strides, 80% of the financial institutions that have the biggest impact on the livestock industry are still dormant. A permanent decline in the value of financial institutions' loans and investments could result from lower profitability, more erratic earnings, and possibly stranded assets. Establishing financial mechanisms that enhance credit access for farmers using best practices in the cattle supply chain, for example, can increase productivity while reducing pressure on natural ecosystems, even though there are risks to one's finances and reputation. Additionally, these processes lower credit risks, raise farmer incomes, and improve production. Fortunately, leaders in the financial sector have successfully implemented robust data management practices and established high-quality standards. The Deforestation-Free Finance Roadmap is one of the resources available; it outlines the regulatory requirements that financial institutions must adhere to along the cattle supply chain in Brazil and offers crucial information and tools for risk assessment and management in the Brazilian context (Carvalho, 2025).

For financial institutions to evaluate and control risks in the Brazilian context, the Deforestation-Free Finance Roadmap offers crucial data and resources. With current best practices at hand, this is the ideal moment for financial institutions that have not yet begun the required transition journey. After taking the initial step, institutions might undergo a transition in four years, according to the Roteiro de Finanças Livres de Desmatamento (Finance Sector Roadmap) (Deforestation-Free Finance, n.d.). Originally introduced by a group of top sustainable finance professionals, it is now more widely available and tailored for Brazilian financial institutions. However, little has been done in some areas to stop the ongoing increase in forest loss, even though international targets to reduce deforestation have been in place for decades. Deforestation rarely happens in a governance vacuum; political and legal processes either facilitate or discourage deforestation. It has been questioned whether the current policy approach, which uses quantitative target-setting, is a viable means of enacting significant and revolutionary change in land-use regulation (Almeida, Lagoa and Vasudhevan, 2024).

Economic pressures operate on several levels and interact intricately with other factors that contribute to deforestation and the deterioration of forest ecosystems, including poverty, unstable land tenure, inadequate institutions and governance in the forest sector, a lack of cross-sectoral cooperation, and illicit activities. Forest and land-use governance

will remain rife with problems that facilitate and intensify resource exploitation and forest loss unless these fundamental factors are addressed with an emphasis on equality, justice, and inclusion. It takes a lot of work and experience to take into account and balance all these intricate elements, in addition to processing a vast amount of data. The intricacy and nonlinearity of underlying causes are frequently missed by traditional regression techniques. In response, it is important to highlight how AI is more effective than traditional techniques at tracking, forecasting, and controlling deforestation and forest degradation in order to support international efforts to conserve forests. In this case, public management may benefit from AI-based solutions. Through predictive modeling, real-time monitoring, and support for forestry initiatives, artificial intelligence is being utilized to fight deforestation. Artificial intelligence (AI)-powered systems examine aerial photographs, satellite pictures, and other data to identify deforestation early, forecast high-risk areas, and track illicit activities like logging. In order to stop forest decline and encourage forest recovery, this enables quicker and more focused actions (Hasan *et al*., 2024).

When evaluating the broader implications, the development of predictive, preventive, and restorative methodologies underscores AI's potential as a powerful tool in combating deforestation. Large-scale datasets from satellites, drones, and ground sensors can be analyzed by AI-powered systems to identify illicit logging, forecast patterns of deforestation, and maximize reforestation initiatives. Specifically, AI is being utilized to create deforestation prediction models. Based on variables including population density, infrastructural development, and land use patterns, these models are able to pinpoint regions that are more vulnerable to deforestation. The most vulnerable locations can be the focus of interventions, and conservation efforts can be prioritized using this information. AI-powered technologies are able to choose the best tree species for particular locations, find optimal reforestation spots, and track the progress of reforestation. Reforestation initiatives can be made more successful and sustainable with the use of this knowledge (Sutriani *et al*., 2024).

Deforested regions can be identified by processing satellite and drone photographs using computer vision models like Ultralytics YOLOv8. These algorithms are able to identify even minute changes in vegetation and differentiate between various types of land cover. For forest monitoring and conservation initiatives to be successful, this degree of detail is essential. Similar AI techniques that are employed in deforestation can also be used in related fields, like agricultural landscape maintenance and monitoring. In addition to being able to process large volumes of high-resolution imagery and identify minute changes in vegetation, sophisticated models like YOLOv8 may be trained in a variety of tasks, including object detection. These models distinguish between different forms of land cover, including cleared ground, sparse vegetation, and deep forests, using sophisticated algorithms. Accurately determining the extent of deforestation and identifying areas at risk requires this level of detail.

To increase sensitivity to both small- and large-scale deforestation trends in temporal remote sensing data, Benvenuto *et al*. (2024) specifically presented a system that combines a conjugated Dice–Focal loss function, spatial attention mechanisms, and a modified YOLOv8 backbone. Using two datasets from the Amazon region, a comprehensive set of tests was carried out to investigate single-image and image-pair

inputs under various contextual and class balance situations. In comparison to thirteen deep learning techniques, the findings demonstrate significant gains in accuracy and computational efficiency, proving the efficacy of the suggested model in deforestation monitoring settings where accuracy, scalability, and computational cost are all crucial at the same time.

AI in the mining and natural resources market

The total size of the global AI in mining and natural resources market is estimated at USD 5.4 billion in 2024 and is expected to grow at a compound annual growth rate (CAGR) of 20.6% from 2025 to 2034 to reach USD 35.2 billion (InsightAce Analytics, 2025). Figure 1 shows the forecast for global AI in the mining and natural resources market. In mining and natural resources, artificial intelligence has great promise for promoting sustainable practices, increasing operational efficiency, and meeting the world's expanding need for vital natural resources. One of the main drivers of the mining industry is the increasing need for efficient and sustainable resource management. AI's extensive data processing and analytical insights improve decision-making, which lowers operational costs, streamlines exploration and extraction procedures, and has a smaller environmental impact. A notable instance occurred in August 2024 when ABB and Komatsu entered into a collaboration aimed at developing solutions for electrification and decarbonization in the mining sector. The partnership combines the expertise of both companies to offer complete solutions, including fully powered mining vehicles and renewable energy generation. By electrifying mining operations, ABB and Komatsu hope to decrease and eventually eliminate the use of fuel. The businesses will provide a range of interoperable solutions that are customized to meet the needs of the client.

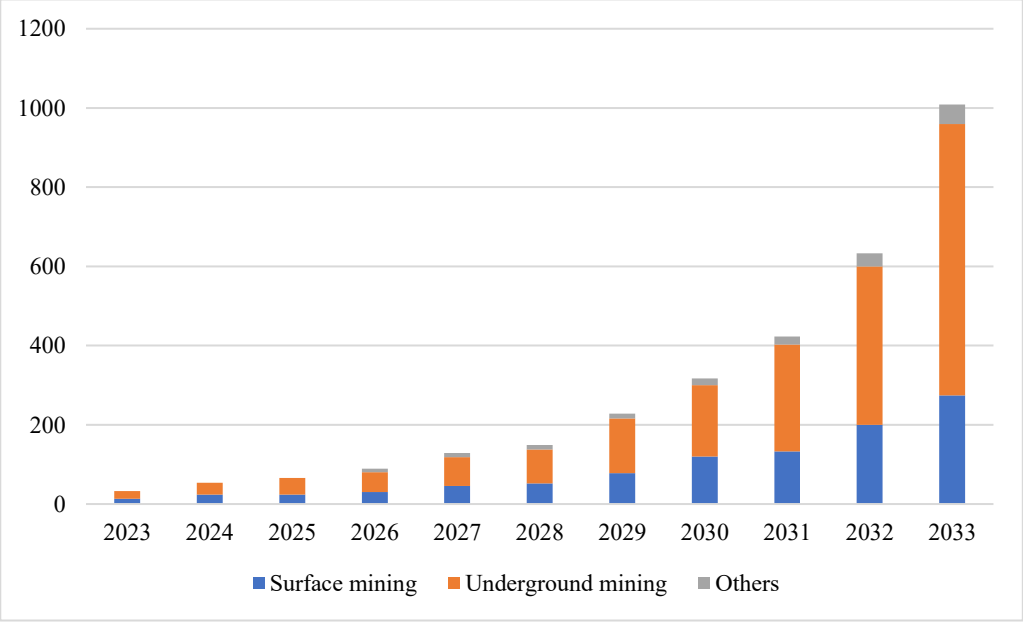

Figure 1: AI in mining market, with forecast (Grand View Research, 2024)

AI computation to address the issues of natural resource management

Adamatti and Agular (2012) state that data management and communication, data analysis, and optimization and control represent the three computational difficulties in natural resources management. Due to their ability to handle the inherent dynamics of natural resources, artificial intelligence approaches could be used to develop computational tools to address the three issues of natural resource management. Numerous methods are available in the literature, including neural networks, genetic algorithms, planning, cellular automata, multi-agent systems, swarm intelligence, and more.

Geographically distributed grid computing technologies, high-performance computing for integrated system modeling, and information systems (GIS) for interactive computational steering are all becoming more and more important in modern resource management. Computer scientists, for instance, are always working to develop better methods for handling the massive volumes of data generated by high-throughput sequencing technology used in genomics. Applied computer science's role in applied biology is frequently restricted to resolving issues with data administration and analysis for molecular biologists. Numerous issues with significant economic, social, and political significance can be found in each of these domains. However, a problem may involve all three areas. For instance, data management/communication may be used to gather information about the occurrence and spread of organisms, data analysis may be used to understand spatial and temporal invasion patterns, and optimization and control may be used to develop strategies to manage exotic species populations.

Governance challenges in the natural resource domain: institutional quality effect

Meanwhile, in addition to individual problems and worries like deforestation, there are structural phenomena, some of which are hard to spot at first glance. These phenomena fall under the category of public management of natural resources (Foyet *et al*., 2024). In recent years, professionals and academics have recognized the importance of governance in the planning of natural resources. The obvious shortcomings of the conventional top-down, bureaucratic, and usually government-led management approaches have actually led many management organizations and administrations to adopt more interactive, cooperative, and multifaceted governance structures over the past 20 years (Lotfalipour and Salehnia, 2022; Wang *et al*., 2023). Numerous novel approaches to decision-making have been tried in response to this disruption in societal governance, with varying degrees of success and influence on social-ecological outcomes. A lot of discussion on what makes for good governance in the management of natural resources accompanied this paradigm shift. Nevertheless, research indicates that putting these concepts into practice continues to be a major obstacle to the effectiveness of natural resource management (Antonescu, 2023; Ghimire, 2019).

The frequency of governance challenges increases the likelihood of governance network failure and significantly limits the capacity of natural resource governance systems to meet ecological, cultural, and socioeconomic objectives across scales. Enhancing the operation of governance systems in areas where environmental degradation continues despite significant foreign investment in innovative approaches to achieve environmental goals and on-ground initiatives is necessary to safeguard the

sustainability of natural resources (Soliman and Nasir, 2019). In most cases, a number of interconnected governance issues must be resolved before a system can accomplish its goals, even if there may be just a few barriers in the way. Disagreements between interested parties, a lack of funding to implement particular strategies, a lack of government support for specific green initiatives, or a failure to incorporate or use indigenous knowledge to better understand ecological systems are all examples of governance issues (Wang, Li and Razzaq, 2023). Environmental deterioration has continued worldwide despite significant efforts in recent years to identify and address these governance issues. It shows that the insufficiency of global natural resource governance frameworks to respond to environmental pollution and management issues necessitates improving efforts to mitigate environmental deterioration.

Alsagr and Ozturk's study from 2024 investigates how resource rent and institutional quality affect green investment. The findings showed that resource rent had a negative impact on green investment, while institutional quality had a positive impact. However, there are often negative effects on green investment from the interaction terms between resource rent and institutional quality. While FDI and the consumer price index impede green investment, GDP, carbon emissions, trade openness, and ICT encourage it. Using 51 of the top green investing nations between 1996 and 2021, this study examines the impact of resource rent and institutional quality on green investment using the random effect and 2SLS methodologies. According to the analysis's estimates, resource rent deters green investment. On the other hand, green investment is boosted by political stability, government efficacy, corruption control, the rule of law, voice and accountability, and regulatory excellence (Shchokin et al., 2023). Regarding the parameters of interaction between resource rent and other institutional quality metrics, the majority of them are detrimental to green investment.

Natural resource rents and green investments have a complex and multifaceted interaction. "Natural resource rents" are the proceeds from the exploitation and sale of natural resources such as minerals, oil, gas, or lumber. Historically, countries with abundant natural resources have relied heavily on these rents, which could present challenges for green investment (Jahanger *et al*., 2023). On the one hand, nations that depend too much on extractive industries may suffer from the "resource curse", a condition that leads to economic instability, corruption, and environmental damage. Corrupt authorities, criminal organizations, and terrorist networks continue to profit from the illegal trade in natural resources, which also takes funds away from security, development, and the general welfare.

Green industries and resource rent: oppositely directed vectors

Every stage of the extractive value chain is susceptible to corruption concerns, including commodities trading, governmental spending, regulation and administration of operations, awarding of mineral, oil, and gas rights, and revenue collection and management. Therefore, deciding whether natural resources may help or hurt the nation depends heavily on how extractive enterprises are governed. This dependence may hinder the expansion of green investments because of a possible overconcentration of political and financial resources on the exploitation of non-renewable resources. However, it is becoming more widely acknowledged that investment in green industries

and diversifying economies away from resource dependence are crucial for sustainable growth (Zhou *et al*., 2022).

Some countries with a wealth of natural resources have started to finance and encourage green development using the rents from those resources. Saudi Arabia, the United Arab Emirates, Kuwait, and Qatar, for example, have established sovZhaoereign wealth funds to finance renewable energy or infrastructure projects because they depend on oil revenue (Krupa, Poudineh and Harvey, 2019). The transition to a greener economy also calls for significant investments in energy-efficient technologies, renewable energy infrastructure, and sustainable behaviors. These environmentally friendly initiatives could be financed by natural resource rents (Bashir *et al*., 2023). Thus, by redirecting a portion of the profits from non-renewable resources into sustainable and environmentally beneficial projects, this may create green jobs, create new economic opportunities, and mitigate the negative impacts of resource exploitation, all of which have a positive impact on financial security.

The direct effects of natural resource exploitation are not the only harm done to the environment. Long-term impacts on ecosystems and human health are also possible. Resource extraction pollution can contaminate water and air sources, endangering ecosystems and human health. Regarding how to best address these environmental issues, scholars cannot agree. Some contend that in order to lessen the harm brought about by the overexploitation of natural resources, stronger laws and conservation initiatives are required. Others support the creation of alternative energy sources and the shift to a circular economy, in which resources are not exploited and consumed but are instead recycled and reused. Despite disagreements, everyone agrees that excessive use and exploitation of natural resources have detrimental effects on the ecosystem. To solve these issues and implement sustainable practices, policymakers, corporations, and individuals must engage proactively. By doing this, we can ensure that future generations have access to both environmental preservation and economic development in a balanced manner.

It is also critical to address the corruption concerns in extractive industry regulation and promote transparency throughout the whole decision-making process, from new laws and bidding to rules governing income management and expenditure. Participation in the development of policies and regulations concerning the exploration, exploitation, and distribution of oil, gas, and mining benefits, the adoption of clear rules governing the negotiations between the government and extractive companies during the licensing process, and stronger oversight by the government and civil society are also essential (Martini, 2015).

With numerous conflicting rights, users, and governance structures, as well as a large range of actors at various levels and across a wide range of temporal and geographical scales, the governance of natural resources is a complex process. Because of this complexity, the government must be adaptable and agile, with systems that are deeply rooted in the local political economy and that can react swiftly to change. In an environment where natural resource governance increasingly entails decentralized arrangements, such an adaptive management approach is likely to accommodate the interaction between the realities of the field and the application of the sector's governance frameworks. Community-based natural resource management (CBNRM) is one such approach that aims to empower rural

communities and beneficiaries while adding a degree of complexity to the management of natural resources. These governance challenges highlight where AI-enabled monitoring could close enforcement gaps.

The role of decentralization

Decentralized arrangements are a common feature of natural resource governance; however, because of the nature and extent of power-sharing, which transfers insufficient authority and resources to decentralized structures, these arrangements have not always resulted in improvements in the sustainability of natural resources. Elite capture, which reflects prevailing power dynamics in communities and the appropriation of advantages by state actors under state-governed regimes, is also commonly linked to community-based natural resource management. Long-term financial support, as well as robust, appropriate central government support in the form of legislation and technical aid, are crucial for the governance structures of natural resources (Subair, Prianto and Amri, 2025). Building confidence between the government and resource users, as well as lowering the possibility that people with more wealth and influence will seize control of community-based structures, are two benefits of "bridging" organizations like non-governmental organizations.

Because of their decentralized structure, the diverse range of interests and goals they represent, and the connection between many realms of power, governance systems that supervise the management of natural resources are also complex. In order to enhance the already existing variety of views, stakeholders' allocation of resources, influence, and organizational level needs to be more equal. The power relationships among stakeholders may have a big influence on how well governance frameworks for managing natural resources work. There is broad scholarly support for the notion that transnational actors embedded within governmental structures are responsible for good environmental management. However, it is still challenging to establish and maintain such a governance structure, which restricts how well these systems can improve environmental factors. A thorough grasp of the local power dynamics and incentive systems in each of these distinct shadow value chains is essential for improving interventions. Alongside this understanding, there should be a greater focus on how global networks and players support and enable illicit private benefits. AI-based solutions can be of sound benefit in solving these extremely complex tasks.

By facilitating data-driven decision-making, increasing efficiency, and improving monitoring, artificial intelligence significantly contributes to transparent natural resource management. Furthermore, integrity actors now have more opportunities to improve the effectiveness and impact of their work thanks to the development of generative AI, and in particular, LLMs. Integrity actors can benefit greatly from the assistance of LLMs in automating specific fraud detection tasks, such as searching documents and data sources for possible threats. Although not specific to integrity actors, LLMs can assist auditors and investigators in a variety of operational tasks that hold special promise, given the large amounts of data and paperwork that audit, anti-corruption, and investigative organizations usually handle. LLMs and generative AI hold promise for bolstering various anti-fraud and anti-corruption initiatives.

AI can specifically aid in the development of a model that explains the collusion between resource companies and politicians. This is especially crucial because, although corrupt governments in resource-rich nations have a major detrimental influence on the welfare of their citizens and the financial stability of their nations, very few scholars have looked at the relationships between these governments and resource corporations. This is especially true in post-Soviet space, resource-rich nations in Africa, etc. Politicians are entitled to a portion of the concealed revenue generated by underreporting production, even though resource firms can reduce tax payments by doing so. Underreporting of production volume due to corruption reduces tax revenues that could otherwise be used to enhance the welfare of the populace and the financial stability of the nation.

The availability and quality of data are essential for the successful application of AI against corruption. Managing extensive public consultations and using satellites for remote sensing are two exciting new applications of AI in anti-corruption efforts. Select audits and episodic spot checks can be transformed into more thorough, effective, and real-time monitoring initiatives with the use of AI. In this vein, data on AI-based monitoring of natural resources use and concerns can be combined with the reporting and accounting data on specific public management bodies, and thus complex patterns and correlations can be revealed, showing state-of-the-art and allowing for finding ways for improvement within the field of responsible and efficient use of natural resources, in particular within the landscape of national financial security.

Environmental regulations potential

Without a doubt, strict environmental regulations can be extremely helpful in reducing the destructive effects on the environment of rising energy use from conventional sources. The idea behind stricter environmental regulations is that they lower energy intensity, which enhances environmental quality by lowering greenhouse gas and carbon emissions. Therefore, a basic idea is that environmental governance yields at least two positive results, similar to the strictness of environmental policies. The former is more focused on enhancing environmental qualities in the future and is linked to energy efficiency. On the other hand, corruption in the use and exploitation of natural resources, as well as rent-seeking activities, are encouraged by inadequate environmental governance. As developed economies outsource the manufacturing of dirty commodities to emerging ones, such practices also draw dirty foreign investment. Due to the direct involvement of emerging economies, this process causes environmental damage in these countries. As a result, every economy can benefit from the enforcement of environmental regulations.

Conclusions

The research demonstrates that by improving productivity, precision, and sustainability across a range of sectors, such as forestry, agriculture, and wildlife conservation, artificial intelligence is revolutionizing the management of natural resources. Making smarter decisions, allocating resources more effectively, and automating data analysis are all made possible by AI algorithms, especially machine learning. Effective AI and ML solutions contribute to overcoming the ‘resource curse’, in particular due to increasing transparency. Current environmental issues demand a fundamental change in

the way we value and manage natural systems, not just small fixes. AI has the potential to be an effective instrument for this change.

AI significantly improves the efficiency and transparency of natural resource governance. Governments and organizations may enhance resource management, fight corruption, and advance sustainable practices by utilizing AI's skills in data analysis, automation, and predictive modeling.

The most important issue in the subject is incorporating resource-related problems into studies of stability, justice, and post-conflict reconstruction, as well as providing a comprehensive micro-perspective on hybrid resource governance frameworks. It is an important topic for researchers to focus on. The micro-level complexity of governance and socioeconomic dynamics should not be underestimated. The research should focus more on the geographical and political-economic ramifications of diverse resources, particularly the function and impact of the financial industry and, as a result, the rhetoric of financial security.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*	*Author 6*
Conceived and designed the research or analysis	Yes	No	Yes	Yes	No	No
Collected the data	No	No	Yes	Yes	Yes	Yes
Contributed to data analysis and interpretation	Yes	Yes	No	No	No	No
Wrote the article/paper	Yes	Yes	No	No	No	No
Critical revision of the article/paper	No	Yes	No	Yes	No	No
Editing of the article/paper	No	Yes	Yes	No	Yes	Yes
Supervision	No	No	Yes	Yes	Yes	Yes
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