Environmental Safety as a Cornerstone for Environmental Sustainability: Case Study of Kazakhstan's Zhambyl Region

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Environmental Safety as a Cornerstone for Environmental Sustainability: Case Study of Kazakhstan's Zhambyl Region

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Abstract: This study examines the role of environmental safety in achieving sustainable development, focusing on the environmental safety system's functionality within the Zhambyl region of Kazakhstan. Employing a multidisciplinary approach, the research integrates statistical analysis of environmental indicators, comparative regional assessments, and policy analysis. Data from the Bureau of National Statistics and various policy documents informed the evaluation of environmental safety's efficacy at regional and national levels. Key findings reveal significant gaps in the regulatory and legal frameworks that impede effective environmental management, highlighting critical areas for policy optimization. Notably, pollution metrics, such as air emissions, identified the industrial city of Karatau with an index of 7.39, indicating severe environmental degradation. The study concludes that an enhanced environmental safety policy, integrating innovative management tools and digital monitoring systems, is essential for Kazakhstan's transition to a sustainable environmental strategy.

Keywords: environmental policy; environmental safety management; sustainable development strategy; environmental security indicators; natural resource

1. Introduction

The issue of environmental safety is of paramount importance, with over 40% of Kazakhstan's natural ecosystems exhibiting significant signs of degradation as a consequence of prolonged anthropogenic pressures. This crisis highlights the imperative of prioritising environmental sustainability within Kazakhstan's national development strategy. The country's security policy now identifies environmental sustainability as a core objective, aligned with the global trend of ecological integration and socio-economic adaptability. The sustainable development goals place an emphasis on halting ecosystem degradation and mitigating adverse impacts. This requires the implementation of innovative regulatory tools that integrate preventive environmental safety measures.

The works of some scholars, particularly A.E. Ibrayeva[1)], substantiate the priority of ensuring environmental safety at the regional level. The author analysed the priority concept of environmental sustainability and the prospects for implementing the potential of hydrogen energy in Kazakhstan based on global practical experience. Representatives of the modern scientific community of Kazakhstan, A.B. Bigaliev et al.[2)] examined the practical European experience in optimizing state environmental policies, focusing on the convergence of fundamental principles and existing regulatory instruments for environmental safety. The researchers emphasize the importance of studying natural and anthropogenic ecosystems to address the ongoing challenge of conserving biological resources for the sustainable development of Kazakhstan's regions.

G. Assanova et al.[3)] posited environmental improvement mechanisms adapted to the realities of Kazakhstan. The authors analysed the environmental problems of the Republic, identified the vectors of priority optimisation, and assessed the effectiveness of environmental safety policy at the national and regional scales. At the same time, N. Suleimenova[4)] analyses the potential of the current global trend of digitalisation of environmental activities. The researcher focuses on the need to implement digitalisation tools for monitoring, controlling and making management decisions within the system of ensuring environmental sustainability in Kazakhstan. L.M. Bekenova and G.Zh. Seithamzina[5)] investigated the concepts of implementing environmental sustainability policies in convergence with urbanisation processes at the regional level in developed countries. The

researchers believe that achieving the sustainable development goals necessitates prioritizing the reduction of environmental impact. This includes implementing measures to improve air quality, enhance waste management, and maximize the conservation of natural resources. Such actions are essential for creating a healthy and sustainable living environment.

The associated risks and challenges were explored by G.A. Stamkulova[6], where the scientist analysed the organisational and legal framework decisions in the context of environmental safety. The author addressed the problematic issues of regulatory and legal support for waste management, which are a priority part of the problem of ensuring environmental safety in the region. G. Kalkabayeva[7] analysed the potential for intensifying green finance in Kazakhstan in the context of digital development. The author studies the main sources of financing green projects within the framework of environmentally sustainable activities. The researcher concludes that it is a priority to create a targeted platform for financing projects to optimise environmental safety, accessible to a wide audience of investors, which will intensify the pace of development of the system of environmentally sustainable activities in Kazakhstan.

The findings of the aforementioned researchers provide a comprehensive overview of the problems, achievements, and current state of Kazakhstan's environmental security system[8,9]. Despite their importance, the prioritization of promising areas for optimizing the country's environmental policy has not been fully established, and the issues related to transforming approaches to ensuring environmental safety remain poorly understood. At the same time, Kazakhstan's adoption of a sustainable development policy vector requires the appropriate development of effective tools for managing regional environmental safety. The paradigm of green development in the context of global integration sets the achievement of a balance between socio-economic and environmental development as a key priority[10].

The objective of this study is to analyse the role and functionality of environmental safety within the broader system of sustainable development in Kazakhstan. In particular, the aim is to investigate the extent to which environmental safety contributes to the attainment of ecological balance and the reduction of degradation in natural ecosystems in the context of socio-economic development. In order to achieve this, the research will focus on:

1. Analysing the current state of environmental degradation in Kazakhstan and identifying priority areas for regulatory intervention.
2. Examining Kazakhstan's environmental policy within the context of sustainable development goals, particularly in addressing ecosystem resilience and mitigating human-induced pressures.
3. Reviewing regional practices and experiences, especially in areas such as the Zhambyl region, to draw comparative insights on environmental safety strategies.
4. Investigating the effectiveness of innovative tools, such as digital monitoring and green finance, in enhancing environmental safety and sustainability.

2. Materials and Methods

This study employs a multidisciplinary scientific approach to examine the paradigm of environmental safety in Kazakhstan. It addresses analytics within historical and spatial contexts, functionality and efficiency, and alignment with the overall direction of the studied industry within the sustainable development concept. The research utilized statistical data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan,[11] strategic policy documents and regulations on sustainable environmental development, research findings from contemporary scientists, and publications from scientific and metric databases[12].

The principles of complexity and systematicity of the study allowed us to reveal the aspects of crisis phenomena in the system of environmental safety as a vector for implementing the concept of sustainable development. Particular attention was devoted to the study of the variability of approaches and consideration of risks in the practical implementation of optimisation measures, and the development of key areas for improving the efficiency of the convergence of resource, economic and environmental components of sustainable development. The basic methods used are analysis, comparison, generalisation and abstraction, which together allowed us to identify the state of dynamics in the study area.

The analysis method was used in the first stage, in the basic part of the study. It was used to comprehensively study certain aspects of the definition of environmental safety and the phenomenon of environmental sustainability. The analytical methods were used to identify the functionality, properties, and indicators of the basic components of the environmental safety system. In synergy with comparison and abstraction, the analysis not only identified the structural elements and basic approaches in the problem under study but also recorded the relationship between them, and the possibilities of convergence to achieve maximum efficiency of the environmental sustainability policy in the realities of the Republic of Kazakhstan.

The study employed a comparative approach to identify similarities and differences in environmental safety policies in Kazakhstan's Zhambyl region, the country as a whole, and in foreign countries. This comparison aimed to establish common features and properties across these different contexts. The methodology of the comparative method involved aspects of content and procedure. In the substantive context, the basis for comparison was theoretical information about the subject of study in

certain indicators. The procedural aspect of the comparison implied a consistent algorithm of operations for grouping and summarising empirical data. Using the method of generalisation, the general properties of the phenomenon under study were specified by moving from the partial component potential of the environmental safety system to the general definition of environmental sustainability, as well as from the characteristics of the environmental safety system of the Zhambyl region to the corresponding general concept of the republic. The method involved drawing conclusions that characterise the situation in the field of regional environmental security in general. Generalisation was carried out in close connection with abstraction.

Scientific abstraction was utilized to develop an algorithm for a comprehensive management and control process regarding the quantitative and qualitative impact of anthropogenic pressure on natural ecosystems. This algorithm forms the basis for ensuring the required level of regional environmental safety. The abstraction method resulted in the development of a system of abstract definitions that comprehensively characterise the phenomenon of environmental safety.

3. Results

3.1 Results of environmental analysis

The concept of systemic environmental safety is based on the ability of the natural environment to maintain a balance in convergence with society and the economy, based on the properties of adaptive regeneration and dynamic interaction in the process of countering endogenous and exogenous challenges and risks. The phenomenon of environmental security implies the implementation of the function of levelling the threat of damage to the environment and the development of socio-economic processes and is also considered as a definition of an acceptable level of protection against potential destructive changes in natural and anthropogenic ecosystems[13,14]. Environmental transformation is a key trend in contemporary social and economic development[15]. Within the sustainable development framework in Kazakhstan, a primary focus is ensuring the country's environmental safety. When analysing the definition of environmental sustainability in the concept of a system, it is necessary to address the hierarchy of its components, while the determining factor of system formation remains the influence of man, whose function is dualistic (anthropogenic influence is the source of most destructive risks for the environment, while at the same time being the creator and embodiment of any management decisions in the field of environmental policy).

The trend of destructive dynamics of the environment in Kazakhstan is caused by several socio-economic and socio-political factors of prolonged action, including the long predominance of resource-intensive industries in the economy, inefficiency of the current environmental monitoring system and the corresponding management paradigm in the industry, disproportionate liability measures for violations of environmental legislation to real losses for the natural environment, financing of environmental projects on a residual principle and lack of motivational system of targeted investment, imbalance in the management paradigm, as well as low level of environmental culture and awareness of the population. Mitigating the consequences of the above-mentioned issues with further stabilisation of the environmental situation in the country is expected to be possible in case of effective implementation of a set of measures within the framework of the environmental sustainability strategy, which includes innovative tools for organising socio-economic processes and integrated management solutions for environmental safety at the regional and national levels[16-19]. The proposed approach ensures an effective transformation of the environmental management policy, stimulates the formation of green economic systems, and offers practical and feasible measures to intensify the green development course of Kazakhstan.

Within the proposed strategy of formation and optimisation of environmental sustainability of Kazakhstan, the priority directions of strengthening environmental safety are rational to use of water resources, the transformation of the energy sector towards the use of renewable sustainable energy sources, decarbonisation of production processes, public regional governance for environmental sustainability, preventive protection and effective regeneration of terrestrial ecosystems, combating desertification and land degradation (Fig. 1).

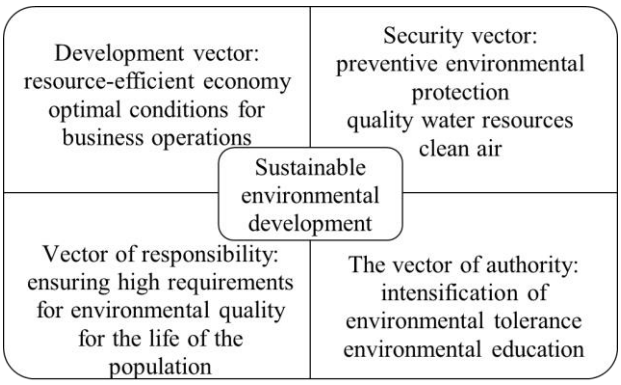

Fig. 1: Directions of sustainable environmental development of Kazakhstan in the context of strategic formation.
Source: compiled by the authors based on[5),7)].

3.2 Comparative analysis

It is necessary to study the role of environmental security in the formation of environmental sustainability in Kazakhstan on the example of Zhambyl region, where the intensity of the impact of economic activity on the environmental situation has reached a significant scale. The situation in the region is representative of the risks of negative processes becoming irreversible, which may make the environment unsuitable for normal life. The

crisis nature of the environmental situation is predetermined by the hypertrophied growth of chemical production and irrigated land, which is a general trend for the whole country. The worsening of the negative dynamics of the environmental situation in the Zhambyl region is provoked by the impact of various factors that together form an indication of the environmental safety of the region. 9 stations in the Zhambyl region continuously monitor the environmental situation. Research conducted in 2022 showed that Karatau is the most polluted city in the region. The pollution index was 7.39. In Taraz, this figure is slightly lower – 5.37 (Table 1)[11].

Table 1. Pollution levels and major emission sources in Zhambyl region (2022).

City	Pollution Index (2022)	Major Emission Sources
Karatau	7.39	Mineral fertilizer plant, HEPP, EuroChem-Karatau
Taraz	5.37	Industrial facilities, Talas Investment Company
Zhambyl Region Average	6.20	Aggregated regional industrial activity

Source: compiled by the authors based on[11].

Table 1 summarizes pollution indices for key cities in the Zhambyl region, highlighting the primary sources of emissions contributing to environmental impact. This data underscores the need for region-specific environmental management strategies to mitigate pollution effectively.

Air emissions from large enterprises such as the mineral fertiliser plant, Zhambyl Baturov Hydroelectric Power Plant (HEPP), Zhasyl-El Taraz, Talas Investment Company, EuroChem-Karatau and EuroChem-Udobreniya require constant monitoring of air outside sanitary protection zones, as well as the introduction of an automated emissions monitoring system as a basis for ensuring environmental safety of the region in terms of air. At the same time, only the Baturov GRES is connected to the National Environmental Data Bank.

A comprehensive analysis of all factors influencing the environmental situation in the Zhambyl region revealed the necessity to mitigate the negative impact of economic activities on the environment to ensure environmental safety. This requires a revision of the entire water policy in the region and the implementation of fundamental environmental protection measures aimed at reducing harmful emissions from industrial enterprises and the production of depleted mineral fertilizers. In the process of analytical comparison of the level of development of the environmental safety system in Kazakhstan on the example of Zhambyl region with the situation in developed countries, it is necessary to note the predominant practical role of economic instruments of environmental safety regulation in European countries. The most effective measures in this concept are environmental taxes and duties, eco-labelling of products, an emissions register, and financial mechanisms for improving environmental policy. In developed countries, the environmental policy of safety and sustainability, unlike in Kazakhstan, has a practical targeted focus, using strict control and damage compensation measures, targeted investment, and economic measures that complement the legislative framework, involving stakeholders at different levels of management and socio-economic activity.

3.3 Trends and patterns

The strategic resource of regulatory and financial instruments governing environmental safety and sustainability in developed countries is steadily expanding, based on the principles of consistency and prolongation. The experiences of Germany, Austria, Denmark, Estonia, Sweden, and Sweden serve as examples of successful implementation of the environmental policy concept. Germany is recognized as a global leader in the fight against climate change and decarbonization. In 2023, the level of greenhouse gas emissions was almost half of the 1990 level, which indicates the significant effectiveness of the national environmental security policy[20]. Since 2016, Austria has been the largest producer of renewable green electricity (over 70%)[21]. Denmark, in synergy with Austria, leads in the development of the energy sector and is an unparalleled leader in wind energy, boasting the highest number of registered wind energy companies. Since 2015, Denmark has produced 42% of all electricity consumed in the national space, while the country's development strategy until 2028 envisages the production of 100% energy with a zero-carbon footprint.

Sweden's environmental safety policy is based on minimising waste generation and maximising recycling. The country is a leader in waste management, with 0.7% of its waste going to landfill. The result is achieved by sorting 99% of household waste, with half of it used for energy generation[22-24]. Estonia is currently determined as one of the cleanest countries in Europe, which is also due to effective strategic waste collection and recycling programmes. Estonia has large landfills and recycling facilities[20]. The experience of developed European countries serves as an excellent example for Kazakhstan, demonstrating the successful practical implementation of environmental safety policies as a guarantor of environmental sustainability.

Moreover, the implementation of European legal norms and financial instruments into national environmental legislation requires modelling based on predictive performance in the realities of the Republic. The process of achieving environmental sustainability involves the rational and efficient use of the region's resource potential, addressing the current state of environmental safety in Kazakhstan, which, if properly converged, can ensure development towards sustainability and environmental safety. Among the necessary measures to optimise the situation, it is necessary to ensure conditions for maintaining ecological balance, introduce an effective

system of preventive environmental protection, use innovative waste management systems, transform the resource use algorithm in the concept of preventing negative impact on the natural potential, implement protective measures, and eliminate the risks of emergencies.

The greening of socio-economic systems should be carried out in the direction of preventive protection by limiting resource use, monitoring the state of environmental parameters, independent audit of ecosystem sustainability indicators, modelling and forecasting major risks and threats, and introducing the practice of licensing and certification of certain activities[20-25]. Optimisation of the waste disposal and recycling system is also a promising area for ensuring environmental safety in Kazakhstan. The synergy of efforts in the proposed areas will gradually achieve the restoration of the natural environment, ensuring the transformation of the republic's environmental policy towards sustainability. Table 2 outlines the prospects for enhancing Kazakhstan's environmental security within the framework of the sustainable development strategy.

Table 2. Tactics to strengthen Kazakhstan's environmental security.

Concept	Target
Renewable energy	Increase in the share of total final energy consumption
Resource efficiency of production	Reducing the level of resource and energy consumption of the gross domestic product, renewable resource use strategy
Water quality	Reducing the volume of untreated wastewater discharges, sustainable use of aquatic ecosystems
Protecting coastal ecosystems	Increasing the share of the area of the nature reserve fund, controlling the targeted use of coastal ecosystems
Preventive environmental protection	Ensuring the conservation, regeneration and sustainable use of terrestrial ecosystems, protection against degradation and erosion
Waste recycling	Minimising waste generation, increasing the share of recycled and utilised waste

Source: compiled by the authors based on[2),5),25)].

In comparing Kazakhstan's environmental safety practices with those of other countries, the challenges faced by Ukraine in adapting its security systems to contemporary global trends are particularly illustrative. Both Kazakhstan and Ukraine face the urgent need to integrate modern management technologies that enhance the efficacy of environmental safety measures. However, in order to ensure the effectiveness of these measures, it is essential that Kazakhstan adapts its approach to match its unique ecological challenges and socio-economic landscape. This comparative view emphasises the broader context of adapting public administration for environmental resilience, showing that effective environmental safety requires robust regulatory frameworks and collaborative efforts between state and society.

In Kazakhstan, public administration in the face of current environmental safety challenges requires a competent convergence of efforts from state and local authorities, the private sector, and society to identify threats and devise prompt solutions. Special attention should be given to preventive measures to mitigate threats during the planning, organizing, and controlling phases of management decisions. This includes utilizing modern information systems and digitalization tools, along with a robust monitoring and control system. Emphasis should be placed on a partnership approach, where the state and citizens are equal participants in the relationship. The conceptual foundations of such cooperation within the context of environmental safety are reflected in the trends of decentralization, adaptability, and digital optimization of management processes (Table 3).

Table 3. Strategic principles of the management paradigm in the field of environmental safety in Kazakhstan.

No.	Principle	Characteristic
1	Democracy	Intensification of the role of the public in the implementation of management activities in the field of environmental safety
2	Decentralisation	Regionalisation of management processes
3	Strategic focus	The long-term viability of environmental safety policy concepts
4	Complexity	Ensuring effective interaction between different levels of government, society and business on the principles of democratic and balanced development
5	Dynamism	Adapting the objectives of the environmental management system to meet current environmental safety challenges

Source: compiled by the authors based on[3),20)].

The environmental safety management system, serving as the foundation for sustainable environmental management, necessitates the introduction of innovative digitalization technologies[26)]. Primarily, the application of these technologies in monitoring environmental safety is justified. Modern satellite systems enable real-time monitoring, creating the prerequisites for an effective and efficient response to environmental threats[27)]. The digital optimization process involves not only automating routine

environmental safety management tasks but also significantly enhancing the openness and transparency of public authorities' environmental management activities[28]. Mobile applications, chats, and specialized platforms facilitate public access to information about government and public institution activities, thereby stimulating public control processes and identifying pressing issues[29,30]. Consequently, public administration concerning environmental safety leverages digitalization and the latest technologies to significantly optimize the preventive environmental protection system. However, potential risks associated with digitalization, such as privacy breaches and cyber-attacks, must be considered.

Reforming the governance system in the context of environmental safety requires the gradual adaptation of existing legislation to new forms of interaction between society and the state, as well as corresponding dynamics in the functioning of state authorities and local self-government bodies. Achieving these goals involves developing and implementing national and regional environmental safety programs based on principles of transparency and public accessibility. The relevant concept should incorporate tools for active preventive protection and mitigation of external threats to environmental safety. Among the priority areas of the management paradigm in the context of environmental safety, monitoring and promptly neutralizing both external and internal threats and hazards are particularly importance (Fig. 2).

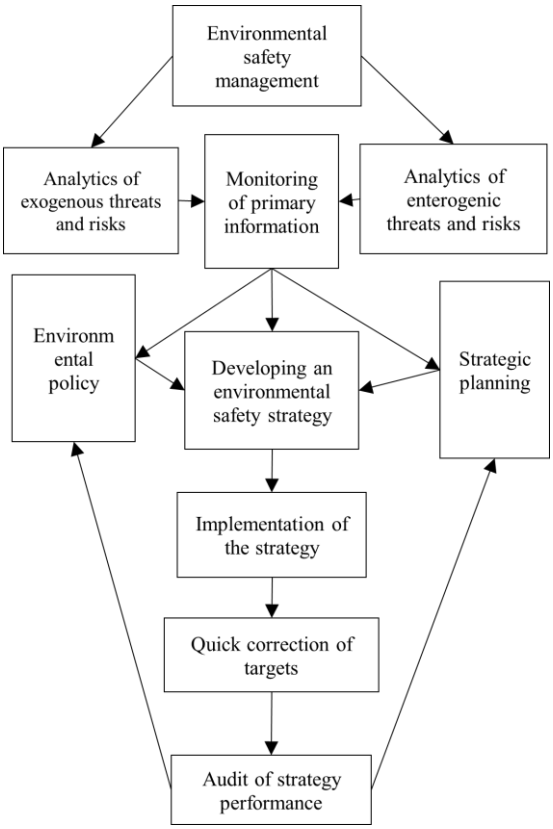

Fig. 2: Algorithms of environmental safety management.
Source: compiled by the authors.

Analysing Fig. 2, it becomes evident that the implementation of the management paradigm for ensuring environmental safety hinges on monitoring as the foundation for objective analysis, forecasting, and systematic assessment of safety criteria and potential threats. Such monitoring establishes the groundwork for promptly enacting measures to prevent, identify, and neutralize risks to the sustainable development of ecosystems. The role of public administration in security encompasses a broad spectrum of functions, including overseeing the implementation and development of innovative technological solutions within the environmental security system through certification and licensing, as well as creating state support programs that foster collaboration among the state, business sector, and society in this field[31]. Given Kazakhstan's strategic orientation towards European and Euro-Atlantic integration, it is crucial to adopt and develop principles and standards for ensuring environmental safety that have been successfully applied in developed countries. For a comprehensive analysis of the feasibility and benefits of implementing international standards and requirements in environmental safety, it is advisable to employ a comparative research methodology for managerial issues, characterized by universality and complexity.

The necessity of thoroughly evaluating the potential for incorporating the successful practical experiences of developed countries into Kazakhstan's national environmental safety practices calls for optimizing the aforementioned methodology using the core principles of institutional theory. This theory structures the social institutions of the external and internal environment of environmental safety and identifies factors significantly impacting the formation of a conceptual framework for environmental sustainability management. Concurrently, developing and analysing a national model of environmental security and establishing a classification typology of managerial culture and the national security system are deemed appropriate. This approach aims to prevent distortions in the implementation of environmental policy when applying foreign practices in Kazakhstan.

Defining the environmental safety management system as a cornerstone for environmental sustainability positions it within the general strategic management paradigm, characterized by a forward-looking focus. The field under study inherently involves conceptual aspects. Consequently, while addressing current environmental safety issues, the environmental management system must simultaneously work on improving the environmental safety strategy. Optimizing the environmental sustainability policy system within the context of national security necessitates implementing a decision-making modelling system that enables timely forecasting of potential adverse consequences and risks. The primary principles for constructing such a system model include openness, adaptability, compatibility with regional and

global management systems, and the ability to filter activities within a developed management process algorithm.

Enhancing the efficiency of the management system in ensuring environmental safety requires foundational steps for introducing innovative technologies and management tools, systems for rapid response to destructive factors, and regular assessment of the strategic course's effectiveness. Additionally, the stages of developing a system for implementing the security strategy should reflect the overarching goal of the process – the internal and external integration of agencies, organizations, and structures in the environmental security sector. Therefore, the function of environmental safety in implementing the concept of sustainable environmental management extends beyond the practical application of the regulatory framework and monitoring. An innovative approach to the environmental safety system encourages collaborative efforts between society and the state, maximizes the potential of digitalization and technological solutions, and synergizes efforts to ensure effective progress towards environmental sustainability. In the future, the role of environmental security and sustainability policy within the broader public administration paradigm is likely to expand, presenting new challenges and risks but also significantly enhancing the effectiveness of national environmental security policy.

4. Discussion

The study's results establish environmental safety as a fundamental component for the successful implementation of sustainable development, focusing on preventive measures and environmental regeneration. The environmental aspect of sustainability synthesises the preventive protection of natural resources, minimisation of environmental degradation, and economical resource use, guided by the principle of environmental responsibility in making management decisions.

Given the situation in Kazakhstan, described in this study, it is expected that the existing management system in the field of environmental policy will need to be transformed. S. Wang et al.[32] affirm that actively employing public administration processes is one of the most effective methods for optimising the environmental safety system. Z. Li et al.[33] highlight the necessity of developing efficient tools for public management to enhance the interaction between society and the state within the environmental safety sector. Additionally, J. Joseph[34] and other scholars argue that such a concept should address and mitigate imbalances in this field, particularly within regional contexts. J. Joseph characterises the definition of environmental security as a quantitative measure of the discrepancy between ecosystem indicators and their optimal values. The author positions the phenomenon of environmental safety as a system of measures to ensure that environmental parameters are within the permissible range of values.

During the analytical phase of the study, a strong correlation was identified between the level of digitalisation in environmental monitoring and control processes and the overall efficiency of the environmental safety system. C. Li et al.[35] corroborate the value of digitalising a substantial portion of management processes within environmental safety. According to various researchers, the primary objective of the digital transformation in public administration concerning environmental safety and sustainability is to collect, safeguard, and optimally utilise data sets. M. Francisco[36] underscores that limited access to modern technologies and reluctance to implement them are significant barriers to the potential of digital transformation in this field. Francisco asserts that ensuring environmental safety necessitates an effective environmental policy, the greening of production processes, and a shift in education towards eco-thinking. These conclusions align with the current study's findings, which highlight an integrated approach as the most effective strategy for transforming environmental policy.

The results of this study underscore the need for effective collaboration between different levels of government, society, and business based on democratic and balanced development principles within a sustainable environment framework. M. Das et al.[37] support this proposed approach, suggesting it enhances the positive dynamics in transforming the management paradigm in environmental safety. Concurrently, A. Arunagiri et al.[38] highlight specific prerequisites for establishing an effective environmental sustainability system, such as the necessary resource base and societal readiness for dynamic change. They argue that economic methods alone can ensure a high level of environmental safety, pointing to a reciprocal relationship between economic and environmental activities. While agreeing with their emphasis on economic methods, the current study contends that the best outcomes in environmental safety can be achieved through a convergence of efforts across political, managerial, regulatory, economic, and public domains.

The key points for ensuring an effective environmental transformation of the socio-economic environment include the use of renewable energy sources, the use of electricity to meet transport needs, the introduction of innovative digital technologies in the energy supply chain and the creation of energy-efficient buildings, as well as a completely new approach to the circular economy as a system with self-healing properties. F. Rotondo et al.[39], in support of the conclusions of the current study, argue that within the framework of a sustainability strategy, any waste is considered a resource, and the system of production, logistics, consumption and disposal acquires a new model. The authors emphasize agricultural and ecological transformation, insisting on the need to minimise the use of pesticides and intensify organic

farming to reduce emissions and prevent environmental degradation.

The importance of environmental safety is becoming increasingly prominent as industry demands grow alongside the need for effective management decision-making systems.[40] In this context, prioritising environmental safety should be paramount. Sustainable management amidst unstable conditions has broadened its scope, demonstrating the efficacy of innovative technological solutions and digital optimisation in this field. Concurrently, S.A. Ashraf et al.[41], as well as Q. Iqbal and N.H. Ahmad[42], explore the optimisation of public administration in ensuring environmental safety. They emphasize the creation of effective mechanisms and the implementation of comprehensive measures to prevent destruction, localise, and mitigate the consequences of conflict situations. For Kazakhstan, the necessary minimum proposed by scientists is not immediately implementable, being positioned as an idealistic theory suitable for developed countries. Given the results of this study, it is necessary to search for an optimum that would allow achieving real efficiency of the processes of transformation of the environmental safety system, ensuring gradual and confident development towards a sustainable environment.

In the context of this study, the term "digital green transformation" is used to describe the integration of digital technologies with sustainable environmental practices, with the objective of optimising resource management and reducing environmental impact. This transformation utilises digital tools, including blockchain, artificial intelligence and big data analytics, to enhance the efficacy and transparency of environmental monitoring and management systems, thereby aligning economic activities with environmental sustainability objectives. It is necessary to address the proposed strategy of digital green transformation of the environmental safety system, which involves the use of the maximum available potential of digital optimisation tools for ensuring environmental safety parameters.

Many scholars, in particular, R. Fenner and T. Cernev[43] insist on the need to prevent potential risks related to digitalisation, including privacy violations and cyberattacks. Additionally, A. Parmentola et al.[44] propose to use the potential of blockchain technology to achieve the goals of environmentally sustainable development, revealing its functionality in terms of improving energy efficiency, creating safe and smart urban areas, and optimising logistics. The authors emphasise that blockchain has no potential negative environmental impacts.

5. Conclusions

The present study sought to examine the manner in which environmental safety indicators can be integrated within the framework of Kazakhstan's national security policy at both local and regional levels. The analysis revealed that Kazakhstan is confronted with considerable challenges, including the depletion of natural resources, unregulated pollution of the air, water, and land, which is largely attributable to intense anthropogenic activity. These findings underscore the critical necessity for the establishment of a robust regulatory framework to effectively mitigate these risks. The results confirm that optimising Kazakhstan's environmental policy is essential to address eco-degradation and support the premise that regulatory and legal support for environmental safety plays a vital role in sustainable development.

The findings emphasise the potential of contemporary digital systems and data-driven management tools to enhance environmental monitoring and mitigate detrimental impacts on ecosystems, thereby aligning economic growth with ecological sustainability. The implementation of digital tools for environmental monitoring has the potential to enhance Kazakhstan's environmental policy and strengthen state-led sustainable development initiatives. Furthermore, the analysis revealed that restructuring the management paradigm to address the dominance of resource-intensive industries and current policy limitations is of paramount importance for ensuring long-term environmental security.

This study offers new insights into Kazakhstan's Sustainable Development Strategy, emphasising that environmental sustainability requires a comprehensive and integrated approach. It is of the utmost importance to achieve a state of ecological and socio-economic balance, while simultaneously promoting active environmental regeneration, optimising the utilisation of natural resources and mitigating environmental risks. The findings indicate that future enhancements in Kazakhstan's environmental security may be achieved by aligning regulatory frameworks with international standards, particularly those that emphasise preventive protection and sustainable ecosystem management.

The limitations of the study were due to the lack of comprehensive quantitative and qualitative data on environmental degradation, which was caused by a lack of motivation and oversight. It is recommended that future research should concentrate on adapting traditional management strategies to the requirements of sustainable development. This is expected to yield practical insights for policy reform and improved environmental governance.

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