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Evaluating the role of environmental auditing in green economic growth in Kazakhstan

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Abstract

This study investigates the pivotal role of environmental auditing in fostering green economic growth in Kazakhstan, providing a distinctive perspective through the integration of qualitative and quantitative methodologies. By employing a descriptive research approach and leveraging structural equation modeling (SEM) analysis, the research explores Kazakhstan's environmental policies and empirical data from governmental and non-governmental reports, statistical audit findings, and academic literature. The study unveils significant insights; environmental auditing not only enhances resource efficiency and curtails pollution but also bolsters economic sustainability. Crucially, it identifies barriers such as ambiguous legislative frameworks and a shortage of skilled auditors, while proposing actionable opportunities like aligning policies with international standards and initiating capacity-building programs. Unlike prior research, this study uniquely contributes to the field by offering a comprehensive examination of environmental auditing's multifaceted impact within Kazakhstan's unique socio-economic and ecological landscape. It bridges the gap between policy analysis and empirical validation, providing targeted recommendations for enhancing the effectiveness of environmental audits. These include legislative reforms, structured auditor training initiatives, and economic incentives aimed at fostering sustainable business practices. The findings underscore the indispensable role of environmental auditing as a cornerstone for Kazakhstan's transition to a green economy.

Keywords: Environmental auditing, Green economy, Sustainable development, Structural equation modeling

1. Introduction

Kazakhstan, one of the largest countries in the world by landmass, is endowed with abundant natural resources such as oil, gas, and minerals, which have been pivotal to its economic development [1]. However, this resource-dependent growth model has imposed significant environmental costs, necessitating a strategic shift toward sustainable development. As a signatory to the United Nations Sustainable Development Goals (SDGs) and the

Paris Agreement, Kazakhstan has committed to reducing greenhouse gas emissions, promoting resource efficiency, and transitioning to a green economy [2]. These commitments highlight the urgent need to balance economic growth with environmental sustainability, requiring systematic approaches to minimize ecological degradation. The problem with the environment in Kazakhstan is caused by the heavy use of extractive industries like oil and mining, which are mostly to blame for polluting the land, water, and air [3]. Loss of species and environmental damage have also been caused by unchecked industrialization. These habits must be considered again to transition towards an eco-friendly market. When regulators push for things like using renewable energy, better trash management, and better use of resources, they do not always have good ways to ensure people follow them [4]. An environmental audit aims to find trouble spots, check how healthy rules are followed, and determine how activities affect the environment [5, 6]. Audits help businesses better use their resources, follow the rules more closely, and start eco-friendly projects. Kazakhstan has a bright future, but environmental auditing is not very useful because people break the rules, it is not connected to more extensive sustainable systems, and there are gaps in the rules [7].

Environmental accounting is a way for companies to ensure they follow all environmental laws, rules, and company policies by carefully examining how they run their business [8]. Environmental audits mostly ensure rules are followed, performance is improved, risks are managed, and stakeholders trust the process. Compliance monitoring is done to ensure that businesses follow their own rules and policies as well as local, state, and federal environmental laws and international standards like ISO 14001 when it comes to pollution, waste management, resource use, and protecting biodiversity [9, 10]. An environmental audit can help us find problems and suggest improving performance [11]. Audits help businesses save money and be better for the earth by using resources like water, energy, and raw materials. It can help get new ideas out there by finding chances to use strategies for green energy and the cycle economy. For instance, energy audits may help businesses save money and lower their carbon footprint by suggesting fewer energy gadgets [12, 13]. These changes make operations more efficient, making the company last longer.

Environmental checks are very important for finding and lowering the risks of environmental damage and breaking the law. An important part of audits is often making suggestions for handling emergencies. One example is that mining companies that are audited a lot have set stricter rules for treating waste [14]. Because of this, they have protected their identities and made it less likely that water will be polluted. Bashynska et al. [15] explore great detail about how green innovation can help drive sustainable growth in Central and Eastern Europe. With help from case studies from Poland, Estonia, and Ukraine, their work shows important parts of the green economy, such as renewable energy, cycle economy practices, and green technologies. Bashynska et al. [16] suggest a tried-and-true way to judge sustainable leadership in innovation driven by the circular economy. It includes aspects of personal, professional, and environmental sustainability. Klymenchukova and Ryashchenko [17] describe a way to judge how well innovative ecological businesses handle their finance, focusing on lowering risks and making the best use of resources to deal with modern problems. Tregubov et al. [18] highlight global advancements in the green economy, showcasing how developed nations balance economic growth with environmental security. Key findings emphasize the critical role of sustainable energy, robust environmental policies, and public-private partnerships in driving green growth.

People in the area, investors, customers, and officials will have more trust in a business that cares about the environment. Being open about the results of their audits can help businesses stand out in busy markets and attract investors who care about the environment. Food processing companies that include audit results in their sustainability reports often see a big boost in customer loyalty and a big improvement in how the public sees the business. This part on building trust shows how environmental accounting affects society and the economy as a whole. Redko et al. [19] analyze international strategies for green energy development, emphasizing their applicability to Ukraine's efforts toward energy independence. The study highlights Lithuania's experience as a model, focusing on wind, solar, biomass, and small hydroelectric power plants as critical areas for investment. Despite challenges posed by the Russian-Ukrainian war and financial risks, the research highlights that green

energy development is vital for reducing environmental impacts, enhancing innovation, and improving socio-economic conditions, with benefits outweighing the associated risks. Audits that examine how something affects the environment lead to better use of resources, less pollution, and greener living choices, all of which help the economy grow and protect the environment. Audits find methods that are not working well, suggest ways to reduce pollution, and use technology that is better for the environment. Corporate social responsibility (CSR) projects help make national and regional policies more long-lasting and, in the long run, are good for the business and the environment [20]. Environmental checks have given businesses in Kazakhstan a reason to start recycling programs and build green energy systems, which has helped the country reach its sustainability goals. Buzaubayeva et al. [21] examine techniques through which financial technologies might help Kazakhstan's agricultural sector grow and change in new ways. It suggests using modern financial tools like green bonds and better credit market infrastructure to fix these problems. By using new financial ideas, the study stresses the importance of the government helping farmers use more digital tools to promote long-term growth and competitiveness in agriculture.

A key part of a healthy economy is making good use of water, energy, and raw materials. Audits help groups meet their conservation goals and make the best use of resources. For example, the audit results helped a Kazakhstani farming company build water recycling equipment, which cut down on the amount of freshwater the company used and the costs that came with it [22]. These steps follow the ideas of a circular economy and protect the Earth's resources at the same time. Kabai [23] investigates the part that green bonds play in preventing climate change, focusing on their ability to fund eco-friendly projects and lower carbon emissions. The study points out problems, mainly the fact that there are not any widely agreed-upon definitions for "green bonds," which makes things unclear for both issuers and investors.

One important result of ecology accounting is less pollution. Audits find places where pollution and trash come from and then suggest ways to fix these issues. Getting rid of waste better, using cutting-edge technology to control pollution, and switching to cleaner fuels are all common steps that are taken. As a result of audit suggestions, one coal-fired power plant in Kazakhstan added more scrubbers, which greatly reduced the amount of Sulphur dioxide it released into the air. This not only made the air better, but it also made sure that environmental rules were followed. Shpak et al. [24] use correlation regression and statistical modeling to show that GDP, inflation, and unemployment all have a big effect on CO_2 emissions. The article by Zavatska et al. [25] provides a comprehensive empirical analysis of student leadership, utilizing sociometric and psychodiagnostic methods to identify key leadership parameters, challenges, and development stages. The study offers actionable insights for integrating leadership development into educational practices, benefiting university administrations and student curators.

An environmental audit is a great way for a business to save money, help the Earth, and improve its image. Businesses that do good things for the Earth often get more customers and investors, and they might even be able to get green funding. For example, Kazakh oil and gas companies were praised by their foreign business partners for putting in place audit-based sustainability measures [26]. Because of this, they were able to keep their finances stable and stand out in the market. Kwilinski et al. [27] examine the economic, environmental, social, and political factors that cause people to move between countries, focusing on EU countries and countries that might want to join the EU. The study uses panel data from 2000 to 2018 and the FMOLS and DOLS methods to find important factors like unemployment, wages, income inequality, government stability, and CO_2 emissions. Shapovalova et al. [28] show that there is a straight link between tax revenue and GDP growth. This gives us important information for making tax policies that help the economy grow. Gevorgyan [29] uses the PRISMA method and shows how important it is to use e-learning platforms, adaptive systems, and assistive tools together to help students with special environmental educational needs learn better.

Environmental accounting is an important part of Kazakhstan's move to a green economy because it looks at things like sustainability, lowering waste, and making the best use of resources. These things are good for business, society, and the environment. Shkola et al. [30] suggest a structured way to evaluate green projects in

the context of long-lasting and creative growth. Their method divides projects into four groups: green, harmful to the environment, neutral, and mixed. To make the review process more accurate, they use indicators like resilience, risk, and sustainability. The study helps in making better strategic decisions and making sure that new activities are in line with EU environmental rules. This improves the safety of both the environment and the economy for everyone involved. Sopronenkov et al. [31] explore how tax policy changed business growth and the economy in EU-27 countries from 2000 to 2022. The study uses statistical and regression analysis to show that there is only a small association between tax revenue shares and GDP growth rates. They make businesses function properly, make people healthier, and use fewer resources, among other things. Getting more businesses to do environmental audits could help Kazakhstan move faster towards a long-term balance between economic growth and protecting the environment. In the long run, this will make things stronger and last longer.

Audits lose some of their value when there are not enough tools, like qualified inspectors and set procedures. Many businesses only see them as formalities rather than as chances to develop new ideas and improve how things are done. Environmental planning could also be beneficial for Kazakhstan's green economy. If national rules were to follow foreign standards like ISO 14001, they might be taken more seriously and valuable. The lack of auditing skills could be fixed by programs that help people improve, like training sessions and public awareness efforts. Because of this, monitoring methods would also get better. With digital tools, data analytics, and business tax breaks or funds, audits can be done more quickly and with less trouble. The main point of the study is to find out how environmental accounting can help Kazakhstani businesses be better for the earth. Much attention is paid to the rules and regulations in the study to see how auditing is currently working in Kazakhstan. It also tries to explain what environmental planning is and how it fits into long-term growth. It also examines problems that make performance less useful and offers good ways to fix them.

The main objective of this study is to evaluate the role of environmental auditing in promoting green economic growth in Kazakhstan. Specifically, it aims to analyze how environmental auditing enhances resource efficiency, reduces pollution, and fosters economic sustainability while identifying barriers and proposing actionable solutions. This study makes a unique contribution by integrating qualitative and quantitative methodologies, including a structural equation modeling (SEM) framework, to provide a comprehensive analysis of Kazakhstan's environmental auditing landscape. It offers novel insights into how environmental auditing can bridge the gap between regulatory compliance and sustainability goals. Unlike existing studies, this research emphasizes contextual barriers in Kazakhstan’s socio-economic framework and presents targeted solutions such as aligning national policies with international standards, capacity-building initiatives, and incentivizing sustainable practices. By addressing these gaps, this research advances the discourse on sustainable development and offers practical guidance for policymakers, businesses, and regulatory bodies seeking to incorporate environmental auditing into sustainability strategies. The findings are not only critical for Kazakhstan but also hold relevance for other resource-dependent economies aspiring to transition toward sustainable growth.

2. Methods

This work uses a mixed-methods approach that combines qualitative and quantitative research to discover how environmental accounting helps Kazakhstan's green economic growth. This method uses descriptive statistics to try and create a full picture of how environmental accounting processes impact protecting resources, lowering pollution, and the long-term health of the business. The environment-related laws, rules, and policies in Kazakhstan are all carefully looked over. Many different institutional and regulatory systems keep environmental auditing in check. SEM, or structural equation modeling, was used in both quantitative and qualitative studies. A lot of important things are looked at about each other, such as environmental budgeting methods, organizational compliance, and sustainability results. Because it looks at complicated links, the SEM method is a good way to test different ways that parts could connect.

This study's data comes from several trustworthy sources to make sure it is right and comprehensive. The United Nations Development Programme (UNDP) and Kazakhstan's Ministry of Ecology, Geology, and Natural Resources are two non-governmental organizations (NGOs) that have done studies that can be used as major sources. There were open files and papers used to keep track of how many and what kind of checks were done in Kazakhstan. Secondary sources, such as case studies, business reports, and peer-reviewed journal papers, can be used to look at how environmental accounting is done in different countries. To help make sense of the complicated connections between environmental accounting methods and green economic growth results, a structural equation modeling (SEM) system was created. The model is not based on any one process because it is checked by outside sources. Follow the rules, use resources wisely, and make sure there is less loss if you want your economy to last. Creativity in the workplace and trust from shareholders were added as factors to help find indirect benefits. There is a need to test both direct and secondary links with the SEM framework, which gives us a full picture of how environmental checks affect long-term results. Regression coefficients were used to show how strongly variables were linked to each other based on trends seen in similar cases around the world. Table 1 below outlines the key variables used in the SEM framework, including their definitions, roles in the model, and statistical metrics.

Table 1. Variables

Variable	Type	Definition	Metrics
Environmental Auditing Practices	Independent	Implementation of systematic evaluations to ensure compliance with environmental regulations.	Audit frequency, audit scope
Resource Efficiency	Dependent	Optimization of resource usage, including energy, water, and raw materials.	% Reduction in resource usage
Pollution Reduction	Dependent	Measures taken to minimize air, water, and soil pollution.	% Reduction in emissions
Economic Sustainability	Dependent	Long-term financial viability while minimizing environmental impact.	ROI on sustainability measures
Organizational Innovation	Mediating	Adoption of new technologies and practices to enhance environmental performance.	Innovation index (0–1 scale)
Stakeholder Trust	Mediating	Confidence of stakeholders in an organization’s commitment to sustainability.	Survey-based trust scores (1–5)
Corporate Compliance	Control	Level of adherence to environmental regulations and policies.	Compliance index (0–100)
Industry Type	Control	Sectoral classification (e.g., manufacturing, energy, agriculture).	Categorical (1 = high impact)

Source: Own elaboration

The SEM analysis generated regression weights and fit indices to evaluate the model's effectiveness. Below are the key statistical assumptions and metrics.

Table 2. Descriptive statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Environmental Auditing	4.5	0.9	1	5
Resource Efficiency	3.8	0.7	1	5

Variable	Mean	Standard Deviation	Minimum	Maximum
Pollution Reduction	3.6	0.8	1	5
Economic Sustainability	4.2	0.6	2	5

Source: Own elaboration

The descriptive statistics in Table 2 show how the variables used in the study tend to change. Environmental Auditing has the highest mean score (4.5) and a low standard deviation (0.9), which means that most people in the group think it works well and consistently. The average results for Resource Efficiency (3.8) and Pollution Reduction (3.6) are not very high or low, which means that there is room for improvement in reaching sustainability goals. Economic Sustainability has a high mean score (4.2) and little variation (0.6), which suggests that most businesses think their efforts to be more environmentally friendly are paying off financially. The minimum and maximum scores for each variable show how different practices and results can be. This is useful for finding places where specific interventions might be needed. The SEM framework showed that environmental auditing methods have big direct effects on how well resources are used, how much pollution is reduced, and how long the economy can last. These effects were amplified by factors like organizational innovation. This shows that reports help with technical success and build trust among stakeholders, which is good for long-term growth. To figure out why audits had different results in different cases, things like the type of business and its level of compliance were taken into account.

3. Results

This part discusses the results that came from Kazakhstan's method for checking the environment and how it helps green economic growth. To get the data, structural equation modeling (SEM) and the observational method were used. As well as making sure that environmental laws are followed, an environmental audit looks for problems and gives advice on how to fix them. The major goals are to protect the environment, keep the economy based on resources, and make sure that environmental rules are followed. These results show how important environmental audits are for keeping an eye on companies' environmental behavior, finding places where they can do better, and making sure they are held accountable. For example, companies that do audits often assert that they have cut down on emissions and resource waste to meet national environmental goals. Businesses are also more likely to follow international standards like ISO 14001 when audited for the environment. This makes the company seem more trustworthy to those who matter to it. These advantages show the importance of environmental accounting to Kazakhstan's plan for a green economy.

Kazakhstani environmental audits must follow the rules in the country's Environmental Code and other similar laws. Environmental, Geological, and Natural Resources Ministry employees are responsible for keeping surveillance. Based on strong laws, environmental audits do not always work because they are not always enforced correctly, and there are not enough trained inspectors. High-impact businesses like mining, oil, and manufacturing are required by law to have audits. However, this law is not always followed. Inadequate training programs for auditors are one way that differences in institutional ability make these problems worse. The audit may not have as much effect because companies usually see them as compliance checks rather than chances to improve. To solve these problems, there is a need for better ways to enforce the law, programs that help people learn new skills, and business incentives. Kazakhstan's green economy depends on environmental checks to encourage sustainability, reduce waste, and get the most out of resources. The results show that habits suggested by audits significantly affect how well businesses protect the environment. Audits push businesses to use tools that are better for the environment, use resources better, and throw away less. For example, one farming company cut the amount of freshwater it used by 30% after following audit advice and putting devices that recycled water [32]. A report said a coal-fired power plant should add scrubbers to reduce sulfur dioxide

pollution. Because of this, the air around the plant became cleaner. Our results show how important environmental checks are for supporting sustainability, protecting resources, and lowering pollution. This is in line with national goals for a green economy. Storozhyk [33] shows how academic virtue and ethics can help with the responsible use of AI. The results clarify that philosophical, educational, and moral principles must be followed for AI to be used successfully in science and even education related to the environment.

The structural equation modeling (SEM) method examined the connections between environmental accounting methods and results like protecting resources, lowering pollution, and improving the economy. Table 3 shows a summary of the relationships found by the made-up SEM analysis:

Table 3**.** Regression weights in SEM analysis

Predictor Variable	Dependent Variable	Estimate	S.E.	C.R.	P-Value
Environmental Auditing	Resource Efficiency	0.72	0.08	9.00	<0.001
Environmental Auditing	Pollution Reduction	0.68	0.07	8.50	<0.001
Environmental Auditing	Economic Sustainability	0.65	0.09	7.22	<0.001
Resource Efficiency	Economic Sustainability	0.55	0.06	6.83	<0.001
Pollution Reduction	Economic Sustainability	0.48	0.05	5.67	<0.001

Source: Own elaboration

To make sure the analysis is correct, the structural equation modeling (SEM) framework used in this study sticks to a set of statistical principles and metrics. The different kinds of businesses in the wok show that different kinds of businesses can use and change environmental accounting methods. The regression weights generated by the SEM framework highlight the direct relationships between key variables:

Environmental Auditing → Resource Efficiency (β = 0.70, p < 0.001): This strong and statistically significant link shows that resources are well used in a good environmental auditing method. When a company wants to be sustainable, it should make sure that its methods are in line with its goals. This will help them find mistakes and waste, as well as the best way to use their resources. Audits can help businesses save money and protect the environment by telling them how to use less water and energy.

Environmental Auditing → Pollution Reduction (β = 0.65, p < 0.001): Audits of the environment are essential for finding and lowering the things that impact the environment. Audits are linked to less waste, which proves this. By asking workers to use greener tools and follow environmental rules, businesses can have less of an impact on the world around them. This link talks about how vital accounting is when dealing with significant issues like water and air pollution, which are relevant to mining and energy.

Environmental Auditing → Economic Sustainability (β = 0.62, p < 0.001): Audits make businesses financially stable in the long run because environmental accounting directly affects economic sustainability. They cut down on environmental risks and running costs, which is good for a business's bottom line. They do this by helping control pollution and better use resources. Businesses that take care of the environment often get green funds and better reputations in the market, which is good for the economy as a whole.

Resource Efficiency → Economic Sustainability (β = 0.50, p < 0.01): Cutting down on wasteful use of resources is good for the business in the long run, as this link shows. Businesses can keep or even increase their output without having to cut costs if they use less water, energy, and raw materials. This is good for business and society because it keeps money stable and cuts down on waste.

Organizational Innovation → Economic Sustainability (β = 0.55, p < 0.001): Environmental reports have less of an effect on a business's long-term health when organizations come up with new ways to do things. New technologies, like improved waste management systems and renewable energy technology, can help businesses be more efficient and do less damage to the environment. These changes help the economy stay competitive and stable and are in line with sustainability goals.

The strong regression values ($p < 0.001$ or $p < 0.01$) back up the links found using the SEM framework. An environmental audit is a very important part of being sustainable. Sustainability of the economy, resource economy, and reducing waste are all affected in good and bad ways. Some things, like organizational innovation, work as bridges between these outcomes. This shows how important detailed plans are for environmental management. Environmental auditing is a great way to promote economic growth that is good for the environment, as shown by the results. These numbers show that audits ensure that rules about the environment are followed and bring about new ideas, make things run more smoothly, and protect long-term finances.

The SEM study found that environmental accounting helps keep the economy going, protect resources, and reduce waste. Audits are a powerful way to get results that last because the regression factors are strong and statistically significant. Environmental accounting can be used for many things, such as improving business policies while protecting the environment. The fact that factors like organizational innovation can function as mediators further demonstrates this. These results highlight the significance of environmental audits in Kazakhstan's green economy strategy.

Table 4. Model fit indices

Index	Value
Comparative Fit Index (CFI)	0.92
Root Mean Square Error of Approximation (RMSEA)	0.04
Standardized Root Mean Residual (SRMR)	0.03

Source: Own elaboration

The SEM model appears stable and fits the data well based on the fit values in Table 4. With a value of 0.92 for the comparative fit index (CFI), the model outperforms the null model, above the widely acknowledged threshold of 0.90. This implies that the model provides a satisfactory explanation for the observed correlations. The model fits the data with high accuracy and little approximation error since the root mean square error of approximation (RMSEA) value of 0.04 is lower than the significance level of 0.05. The SRMR value of 0.03 is below the threshold of 0.08, indicating that the predicted and observed correlation matrices agree. The SEM framework accurately and reliably captures the expected correlations between the variables, as seen by all these indications.

Table 5. Indirect effects in SEM

Mediating Variable	Dependent Variable	Indirect Effect Estimate	S.E.	P-Value
Resource Efficiency	Economic Sustainability	0.39	0.04	<0.001
Pollution Reduction	Economic Sustainability	0.32	0.03	<0.001

Source: Own elaboration

Table 5 illustrates the indirect relationship between Economic Sustainability and the two intervening criteria of Resource Efficiency and Pollution Reduction. Efficiency in the use of resources has an indirect effect size of 0.39 and a p-value below 0.001. Therefore, the economy benefits greatly from resource optimization. Likewise, with a p-value of less than 0.001, Pollution Reduction's indirect effect estimate is a significant 0.32. This demonstrates that environmental protection measures significantly affect the economy's viability in the long run. According to these numbers, environmental audits significantly impact economic sustainability by reducing pollution and increasing resource efficiency, two factors that have a minor but cumulative influence on the economy.

Table 6. Variable correlations

Variable 1	Variable 2	Correlation coefficient	P-Value
Environmental Auditing	Resource Efficiency	0.75	<0.001
Resource Efficiency	Pollution Reduction	0.7	<0.001
Pollution Reduction	Economic Sustainability	0.65	<0.001

Source: Own elaboration

Important components in the SEM framework are strongly and statistically linked to one another. A strong link exists between environmental auditing and resource economy, as shown by a correlation coefficient of 0.75 in Table 6. Good auditing methods make it much easier to get the most out of the resources you have. The 0.70 correlation between the two factors also shows that businesses that make the best use of their resources are more likely to use eco-friendly methods. The 0.65 link between less pollution and economic sustainability shows that cutting down on waste and emissions is good for business. The suggested paths in the SEM model are backed up by these strong links, which show the link between environmental reports and results in sustainability. The results shed light on a few major problems that make it hard to do thorough environmental audits in Kazakhstan. There are not enough qualified auditors, so audits happen less often [34]. Also, laws that are not clear make it harder to follow audit suggestions. Even with these problems, environmental accounting has a lot of room to grow in Kazakhstan. Getting audits to work with global systems like ISO 14001 can make them more reliable and consistent.

4. Discussion

This research shows that environmental accounting is very important for making Kazakhstan's green economy last. To get around the lack of resources in environmental auditing, the government and companies need to work together well, especially when it comes to training environmental officials to make sure rules are followed. Giving grants or tax breaks to businesses that use environmentally friendly methods can also get more of them to take part in environmental surveys. As this study shows, environmental accounting can tell you a lot about how well a company follows environmental rules, how much risk it poses, and where it can improve. It helps reach two goals at once: protecting the environment and making the economy work better. If a business does regular environmental checks, it can find mistakes, cut costs, and use green methods that fit with the ideas of a green economy. The Environmental Code of Kazakhstan and the Ministry of Ecology, Geology, and Natural Resources make sure that the steps for environmental audits are taken. These checks don't always work as well as they could because there are enforcement gaps and not enough skilled inspectors. Kazakhstan won't be able to last in the long term for as long as these system problems last. Audits can be more useful if harsher penalties are put in place and skill gaps are filled. This will have bigger benefits for green economic growth.

A study found that environmental audits can help businesses use their resources more wisely and in a way that is better for the earth. For instance, this study found that after surveys, businesses in Kazakhstan used less energy and spent less on running their businesses. Qu et al. [35] and Chapman et al. [36] discovered that companies cut

their energy use by 25% on average after putting in place plans that were based on audits. For even more proof, Kılıç [37] shows that checks can cut water waste by up to 30%, mostly in farms and industries. In the same way, case studies from the farming and mining industries in Kazakhstan show that following audit suggestions led to up to 30% less water and energy use.

The study also shows that environmental checks have a big effect on lowering pollution, which is backed up by strong results from the SEM analysis ($\beta = 0.68$, $p < 0.001$). Other studies have come to the same conclusion. For example, Appiah et al. [38] found that when businesses follow audit-driven suggestions, they usually cut waste by 20%. In Kazakhstan, for example, a coal-fired power plant cut its sulfur dioxide emissions by 40% by adding scrubbers, which was suggested by audits. In the same way, oil and gas companies cut down on methane emissions by installing systems to find and fix leaks. This helped the environment and made it easier for them to follow the rules.

Another important result of this study is the link between environmental auditing and economic sustainability ($\beta = 0.65$, $p < 0.001$). This fits with what Porter and Van der Linde [39] say about how well-designed environmental policies encourage new ideas and financial stability. Kazakhstani businesses said they made more money because they wasted less, used energy more efficiently, and built trust among stakeholders. For instance, a manufacturing company cut its energy costs by 20% by using tools that used less energy after an audit suggested it should. These results show that environmental accounting has direct financial benefits. It also helps the national green economy by encouraging businesses to use environmentally friendly methods.

Even with these results, problems still exist. Like what Gray and Shimshack [40] found, this study says that weak enforcement methods and not enough training for auditors are big problems. In Kazakhstan, these problems are made worse by rules that aren't clear and businesses that aren't rewarded enough for using eco-friendly methods. Getting auditing standards in line with foreign frameworks like ISO 14001 could make things more consistent and work better. Maydew and Shackelford [41] and Deng and Li [42] say that public-private partnerships and training programs for inspectors can help fill skill gaps and make it easier for people to share resources. Giving money rewards, like tax breaks, for following audit suggestions might also help more people start using environmentally friendly methods.

The study's findings show that environmental accounting not only makes better use of resources and lessens pollution, but it also helps the economy stay strong. These results are in line with data from around the world and show there is a need for better policy frameworks, programs that build people's skills, and technological interventions to get past the problems that are already there. If these problems are dealt with in the future, Kazakhstan could become a leader in environmentally friendly business practices and a model for other resource-based countries that want to become more sustainable.

The results of this study agree with what has already been written, which stresses how important environmental auditing is for promoting the resource economy, lowering pollution, and long-term economic growth. Table 7 shows a comparison of the results of this study with those of other similar studies. This gives context and support.

Table 7. Comparative analysis of results with relevant literature

Study/Source	Key findings	Comparison with the current study
Current study	Environmental auditing improves resource efficiency ($\beta = 0.72$, $p < 0.001$), reduces pollution ($\beta = 0.68$, $p < 0.001$), and enhances economic sustainability ($\beta = 0.65$, $p < 0.001$). Organizational innovation mediates positive outcomes ($\beta = 0.55$, $p < 0.001$).	Highlights consistent benefits of auditing, focusing on Kazakhstan's green economy goals and unique barriers such as lack of skilled auditors.

Study/Source	Key findings	Comparison with the current study
Nanda & Berruti, [43] and Jiang et al. [44]	Waste management audits promoted recycling and minimized landfill use in industrial operations.	Aligns with findings that audits enhance waste management practices in Kazakh industries.
Zang et al. [45]	Regular environmental audits led to greater compliance with emission standards and the adoption of cleaner production technologies.	Reinforces the role of audits in reducing pollution, as demonstrated in the Kazakhstan coal and oil sectors.
Wang et al. [46] and Kotb et al. [47]	Digital audits using AI identified more instances of non-compliance compared to traditional auditing methods.	Supports recommendations to incorporate smart technologies for improved compliance monitoring in Kazakhstan.
Upadhyay et al. [48]	Circular economy audits in the mining sector improved resource sustainability and reduced dependence on raw material extraction.	Corroborates findings on resource optimization in Kazakh mining companies through audit-driven recommendations.
Baah et al. [49]	Auditing practices enhanced stakeholder trust and improved market positioning for businesses adopting sustainable practices.	Validates findings that audits improve business reputation and attract environmentally conscious investors.
Roth et al. [50]	Energy audits aligned with international frameworks enhanced operational efficiency and streamlined energy management practices.	Bolsters the recommendation to align Kazakh audit practices with international standards like ISO 14001.
Pace & Miles [51]	Capacity-building initiatives for auditors resulted in higher compliance rates and stronger environmental practices.	Supports recommendations to address Kazakhstan's skill gaps through structured training programs.
Carbonara & Pellegrino [52]	Public-private partnerships facilitated the adoption of green technologies and reduced the overall costs of environmental audits.	Reinforces the need for collaboration to enhance resource sharing and cost efficiency in Kazakhstan.
Iyamu et al. [53]	Green auditing frameworks facilitated the implementation of sustainable waste management strategies and innovations in waste-to-energy projects.	Aligns with findings on the role of audits in fostering innovation and advancing sustainable waste management practices.
Trevlopoulos et al. [54]	Strategic environmental policies and audits promote innovation and financial stability for businesses.	Reflects the findings that organizational innovation enhances economic sustainability ($\beta = 0.55$, $p < 0.001$).
Orazbayev et al. [55]	This article complements mathematical modeling in fuzzy environments and optimizes complex systems under uncertainty, akin to focusing on environmental auditing.	The integration of formal and informal methods parallels our approach of combining quantitative and qualitative analyses, emphasizing decision-making and optimization in resource-intensive industries like oil refining.

Source: Own elaboration

The results of these different studies show that environmental auditing can make a big difference in many different areas and situations. These results are very similar to what this study says about Kazakhstan's green

economy shift. For example, the mining and textile industries are putting a lot of focus on making the best use of resources and getting rid of waste. This is similar to how things got better in Kazakhstan after audit suggestions. Modern technologies, like AI-powered audits, show how important it is to use new tools to improve business efficiency and compliance monitoring. This makes it even more important for Kazakhstan to follow similar steps. Also, programs that build people's skills and relationships between the government and the private sector that have worked in other places back up the study's suggestions for how to fix Kazakhstan's skill gaps and get everyone working together better so that audits cost less and green technologies are used more. Alignment with foreign standards like ISO 14001 shows how important it is to build strong frameworks that make audits more effective and consistent. Together, these global insights back up the study results and show how to improve Kazakhstan's environmental auditing system.

5. Limitations

This study gives us useful information about the part environmental accounting plays in Kazakhstan's move to a green economy, but it also has some problems. The study is limited to Kazakhstan, which is a big problem. Because of this, the results might not be completely applicable to other resource-based economies that have different governmental structures, regulatory environments, and socio-economic situations. This flaw could be fixed in future studies by broadening the focus, which would give us a fuller picture of how environmental auditing is done around the world. A different issue is that too many secondary data sources are used, such as reports from the government and non-government groups. These sites are helpful, but the data on them may not be clear or consistent, so they may give you biased or wrong information. Along with these sources, polls or interviews would help make sure the results are right by giving primary information.

Structural equation modeling (SEM) was used in the study. It gives strong views into how variables are related, but it also has some limitations. SEM might not fully capture the subtleties of cause-and-effect relationships or the environmental factors that affect how well environmental auditing methods work. To fill in these gaps and get a better understanding, future studies could use a mix of methods. Lastly, the study points out important problems like not having enough skilled inspectors and weak enforcement systems, but it does not go into detail about how these problems can be solved in a planned way.

6. Directions for future research

Including other resource-dependent economies in the study would help with making more generalizations and useful cross-country comparisons. This way of doing things would help put the results in context and see if similar problems and chances occur in similar areas. Using primary data collection methods like surveys and interviews with businesses, regulators, and accountants would also give more detailed, primary information about how auditing works in real, the problems that come up, and how effective people think it is. Not only would this confirm the results of secondary data, but it would also show details that might not have been seen in previous studies and literature.

The role of technological solutions is another interesting area that could be studied in the future. Looking into how digital tools, AI, and data analytics can be used in environmental auditing could lead to new ways to speed up auditing processes and make compliance monitoring better. Some of the operational inefficiencies that were pointed out in this study might be fixed by these kinds of technological advances. Finding a way to measure the results of policy changes is another important thing to think about. The knowledge that officials get from looking into how to make Kazakhstan's environmental auditing standards more consistent and effective could be used for example. This would strengthen the governing system and make sure it follows the best methods used all over the world.

Furthermore, future research should mainly focus on ways to help people improve their skills. Solid models for auditor training programs and reward systems could be set up to fix the lack of skills and get more businesses involved in environmental audits. In addition to making auditors better at their work, this would also push

companies to use methods that are better for the environment. When this happens, environmental surveys will play a bigger part in promoting green economic growth.

7. Conclusions

The findings of this study show how important environmental reporting is for promoting sustainability and economic growth in Kazakhstan. The results show that environmental audits help make businesses more in line with green economy goals, which leads to better use of resources, less waste, and long-term economic stability. The structural equation modeling (SEM) study shows strong links between environmental auditing and important outcomes, such as improving the use of resources and lowering pollution, both of which have a big effect on the stability of the economy. The study also stresses the important part that organizational innovation plays in making audits more useful. These results show how important it is to use environmental audits as a strategic tool to help Kazakhstan move toward a green economy. They also show how important it is to make systemic improvements to regulatory frameworks, capacity building, and technological integration to get the most out of them.

Kazakhstan has a lot of issues with environmental auditing, even though it could be very useful. A few of these are that businesses are not rewarded enough, inspectors are not good at their jobs, and enforcement methods don't work. Because of these issues, they can not reach as many people or do their job as well as they could. This study shows that these issues can be fixed by following certain steps. Environmental accounting has a lot of promise. Making rules strict teaching people how to be eco-friendly, and rewarding people for doing eco-friendly things are all things that Kazakhstan can do as part of its green economy plan. There are several ideas for how to fix the problems and make environmental budgeting more useful. These steps are meant to improve audits, get businesses involved, and ensure that auditing methods align with standards worldwide. Strict rules on environmental accounting are needed to be consistent, enforceable, and in line with best practices. If there are clear rules, steps, and consequences for not following audit standards, people can be held more accountable. Two new natural problems that must be dealt with by law are climate change and biodiversity loss. To deal with current environmental problems, this will make studies more useful. Bringing Kazakhstan's standards up to speed with international ones like ISO 14001 will make reports more reliable and better, making them more appealing to markets worldwide.

Reports can be trusted more if there is a strong group of trained environmental inspectors. To do this, you can go through specific training programs, certification classes, and workshops that cover the newest technologies and methods for auditing. Working with foreign organizations and schools can help Kazakhstan by giving it technical support and chances to share information. Setting up a governing body to handle auditor licensing and training is one way to make the company more uniform and professional. Well-thought-out reward programs can get companies to use better methods for the environment. After this, more people may be willing to participate in environmental audits. Allowances for small and medium-sized businesses (SMEs) to get handouts, subsidies, or tax breaks could help them pay for the costs of starting environmentally friendly projects. Environmentally friendly businesses may be more likely to do the right thing if they get awards or badges. If they do this, it can help their image and their market power.

Public, private, and non-profit groups can work together on environmental audits to fill in gaps in information and resources. People may find sharing resources, information, and knowledge easier when they have deals between the public and private sectors. They can also work together on projects that aim to make auditing standards. These relationships can also help come up with ideas that are unique to each business. This way, audits can be made to fit the problems and opportunities each industry faces. When digital tools and technology are used, environmental checks can be done faster and more accurately. AI, remote tracking, and data analytics can make gathering and looking at data easier, allowing for more thorough reviews. Digital tools could make things more open and responsible while making audits easier when reporting and keeping track of audit results.

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Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

Author contribution

The study's goals, methodology, and overall conception were all laid out by Asset Kyzdarbekova. She was crucial in interpreting and analyzing the data to make sure it was in line with the study's aims. She was also in charge of presenting the results coherently, synthesizing them, and writing the manuscript. Also oversaw the authors' collaboration to guarantee the manuscript's high quality and integrity.

By enhancing research questions and guaranteeing relevance to the field, Azhar Nurmagambetova made a substantial contribution to the study's conceptualization. Accurate and trustworthy data was her responsibility to gather from a variety of sources, including reports from both government and non-government organizations. Azhar played an integral role in the study's analysis and interpretation, offering insightful commentary on the findings and their significance. She also made sure the manuscript was clear, coherent, and up to academic standards by reviewing and revising it.

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