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Research article

Public governance and national environmental performance nexus: Evidence from cross-country studies

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ABSTRACT

This study examines how public governance, including voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption, affects national environmental performance in various countries. It also looks at how gross national income moderates the relationship between public governance and environmental performance. The findings show that political stability and regulatory quality positively influence environmental performance at the national level. In contrast, voice and accountability, government effectiveness, and the rule of law negatively correlate. Furthermore, in wealthier countries, voice and accountability, government effectiveness, and the rule of law enhance national environmental performance, while political stability and regulatory quality benefits diminish as income increases. These results emphasize the importance of the economic context in the interaction between public governance and environmental performance, indicating that wealthier nations are more capable of leveraging public governance for environmental improvements. The study offers crucial insights for policymakers aiming to align public governance reforms with environmental objectives, particularly in countries at varying economic development stages.

1. Introduction

In the past few decades, global attention to environmental degradation has intensified as the consequences of climate change, pollution, and unsustainable resource use have become more evident [1–4]. National environmental performance, which reflects how well countries manage their environmental resources and mitigate environmental harms, has been increasingly scrutinized in light of global sustainability goals [5,6]. One critical area of interest is public governance's role in shaping environmental outcomes. Public governance encompasses various dimensions, such as voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption [7–9]. These elements of governance not only establish the framework for policy decisions but also determine how effectively a nation can address environmental challenges. However, while governance is widely acknowledged as a critical driver of environmental performance, the literature remains fragmented in understanding how different governance aspects interact with economic conditions to influence environmental outcomes across countries.

The research suggests that good governance can lead to improved environmental management, as effective institutions enforce regulations, facilitate public participation, and ensure accountability [10–12]. Yet, this relationship is not linear or uniform across nations. Countries at different stages of economic development may experience varying governance challenges, and economic prosperity may either strengthen or weaken the governance-environment nexus. This raises an important research question: how does a

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nation's economic condition, measured through gross national income (GNI) per capita, moderate the impact of governance on environmental performance? Although the environmental Kuznets curve (EKC) hypothesis provides a useful framework for understanding the relationship between economic development and environmental degradation [13,14], the role of governance within this model has not been thoroughly examined. The EKC posits that as countries develop, their environmental degradation initially increases but eventually declines after surpassing a certain income threshold [15,16]. However, governance may influence how quickly or effectively this turning point is reached, particularly when economic prosperity is factored into the equation.

The problem at the heart of this study is the insufficient understanding of how public governance, in combination with a country's economic prosperity, affects national environmental performance. While it is generally accepted that robust governance systems contribute to better environmental outcomes, this study argues that governance cannot be examined in isolation from a country's economic conditions. For instance, higher levels of economic prosperity might provide governments with the necessary resources and institutional capacity to enforce environmental regulations effectively, thus enhancing governance outcomes. Conversely, in less affluent countries, economic constraints might undermine governance mechanisms, making implementing and sustaining environmental policies challenging. This study seeks to address these dynamics by exploring the moderating role of economic prosperity in the governance-environment relationship.

This study focuses on six crucial dimensions of public governance, namely voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. It also explores how GNI per capita, as an indicator of economic well-being, affects the relationship between these public governance dimensions and national environmental outcomes. The research aims to address key questions: (1) In what ways do different governance aspects impact environmental performance in various countries? (2) How does economic prosperity, particularly GNI per capita, influence the link between public governance and environmental performance? (3) How can the findings of this study lead to more effective governance and economic strategies to enhance global environmental sustainability?

This study addresses a significant research gap by exploring the intricate relationships among public governance, economic prosperity, and national environmental performance. While much of the existing literature tends to examine public governance or economic factors independently, this research emphasizes the necessity of understanding their interactions. Specifically, it reveals the moderating role of GNI per capita, showing that public governance might prove more effective in nations with higher economic prosperity. Conversely, in countries with lower GNI per capita, governance reforms may need to adopt alternative strategies to navigate economic challenges and enhance environmental outcomes.

The contribution of this study lies not only in its empirical findings but also in its theoretical implications. By integrating public governance into the EKC framework, this research suggests that public governance quality could accelerate the EKC's turning point, where economic growth leads to reduced environmental degradation. Moreover, the study offers practical insights for policymakers by showing that public governance reforms must be tailored to the economic realities of each country to enhance national environmental performance. For countries with lower GNI per capita, international cooperation and financial support may be critical to strengthening governance structures and enabling sustainable development. For more affluent nations, the findings suggest that reinforcing public governance mechanisms can further leverage their economic resources to support environmental stewardship.

The novelty of this study lies in its comprehensive investigation of the multidimensional aspects of public governance and their distinct impacts on national environmental performance across 175 countries. While previous studies have often examined public governance and national environmental performance in isolation or within specific regions, this research offers a global perspective, incorporating diverse public governance factors. Additionally, it uniquely explores the moderating effect of a nation's economic prosperity on the governance-environment relationship, providing fresh insights into how economic health amplifies or diminishes governance's role in fostering environmental sustainability. This integrated approach enhances our understanding of the complex interactions between governance, economic prosperity, and environmental outcomes, contributing to the discourse on sustainable development.

2. Literature review

2.1. Historical perspective of the study

The relationship between public governance and environmental performance has evolved as a significant study area, especially as environmental degradation has intensified over recent decades. Early research on environmental governance was grounded in the broader discourse of sustainable development, particularly following the Brundtland report in 1987, which emphasized the need for robust governance mechanisms to address environmental challenges [17]. Since then, studies have begun to explore the role of governance in promoting sustainable environmental outcomes, often highlighting the significance of regulatory frameworks, institutions, and political stability [18,19].

In the late 1990s and early 2000s, research focused more explicitly on the institutional dimensions of environmental governance. Scholars like Ostrom (1990) and Agrawal (2001) laid the foundation for understanding how decentralized governance and community management could influence resource conservation and environmental outcomes [20,21]. At the same time, other studies identified how broader institutional factors, such as government effectiveness, rule of law, and control of corruption, could impact environmental policy implementation and enforcement [22].

By the 2010s, with the growing recognition of the importance of governance in climate change mitigation and global environmental governance frameworks, studies expanded to examine the specific influence of public governance factors on national environmental performance. Researchers began operationalizing governance indicators, such as those provided by the World Bank's

Worldwide Governance Indicators (WGI), to empirically test how aspects like voice and accountability, political stability, and regulatory quality shaped environmental outcomes [23,24]. These studies have consistently shown that higher governance quality correlates with better environmental performance, though the underlying causal mechanisms remained complex and context-dependent.

Despite the expanding body of work on governance and environmental performance, significant gaps and inconsistencies remain in the literature. One of the primary challenges is the varied operationalization of governance and environmental performance across different studies. While many studies use composite indices such as the environmental performance index (EPI) or the world governance indicators (WGI), these indices often aggregate diverse dimensions of governance and environmental outcomes, potentially obscuring nuanced relationships [25]. Furthermore, cross-country studies have often relied on correlations without adequately addressing endogeneity concerns, undermining causal inferences' robustness [26].

Another critical issue in the literature is the lack of consensus on the specific governance factors that most significantly impact environmental performance. While some studies highlight regulatory quality and control of corruption as key determinants [27], others emphasize the importance of voice and accountability or political stability [28]. This discrepancy suggests that governance's role in environmental performance may vary significantly depending on the national context, including economic development levels, institutional capacity, and socio-political stability.

Economic prosperity, in particular, plays a crucial role in moderating the governance-environment nexus, yet it is often underexplored. Several studies have shown that wealthier nations have better environmental performance due to their capacity to invest in cleaner technologies and more robust institutional frameworks [29–32]. However, this raises questions about the generalizability of findings from high-income countries to lower-income contexts, where governance structures may function differently and resource constraints may limit environmental initiatives. This study highlights that the interaction between governance quality and economic conditions requires further empirical attention, particularly in developing countries where governance failures often exacerbate environmental degradation.

2.2. Public governance dimensions

Public governance plays a critical role in influencing a country's environmental performance. The World Governance Indicators (WGI) framework, a widely utilized tool, assesses various governance dimensions to measure their impact on environmental outcomes. These dimensions include voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption [7,8]. While the WGI framework has significantly shaped empirical studies, it is essential to recognize the intricate interplay between these dimensions and environmental performance. For instance, understanding how government effectiveness impacts environmental policy implementation and enforcement can provide valuable insights into enhancing environmental outcomes [33].

A critical dimension, voice and accountability, stresses the importance of political liberties and civic participation [34]. Liberties are essential for individual well-being and societal empowerment [35]. Research suggests that while increased voice and accountability can positively affect environmental outcomes, the impact may not be consistent across all contexts [36]. In politically unstable countries with greater potential for social tensions, the influence of voice and accountability may exacerbate existing issues and hinder effective environmental governance [37]. Instability, often driven by deep-seated ethnic or religious divisions, can lead to governance failures, severely limiting the government's capacity to implement and enforce environmental policies [38]. This can result in significant challenges in addressing environmental issues in these countries.

The effectiveness of a government in implementing policies, also known as government effectiveness, has been found to have a direct impact on environmental outcomes [39]. For instance, a government that is efficient and capable of enforcing environmental regulations and policies is more likely to achieve positive environmental results [40]. However, there is a significant contrast between nations that prioritize the general public's well-being and those that primarily serve the interests of the elite. In countries where the elite's interests take precedence, conflicting economic or political priorities may undermine the government's effectiveness in environmental matters. This raises a fundamental question: does the government's effectiveness in non-environmental areas, such as infrastructure development or economic policy, divert attention and resources away from environmental stewardship, ultimately impacting environmental outcomes?

Regulatory quality, which measures the government's ability to create and enforce effective policies [41], adds complexity to the connection between governance and environmental performance. For example, well-crafted regulations based on thorough scientific research and stakeholder input can promote economic growth while protecting the environment [42]. On the other hand, poorly executed regulations, such as ones that are ambiguous or burdensome, can stifle innovation and create unnecessary obstacles that work against environmental goals [43]. This creates a dilemma for governance systems: how can they ensure that regulations are well-designed and effectively implemented to balance the need for effective regulation without impeding economic and environmental benefits?

Strong legal frameworks are pivotal in promoting democratic governance and environmental progress [44]. Robust legal systems, including legislation, enforcement mechanisms, and judicial oversight, are essential for upholding environmental protection efforts [45]. In countries with weak rule of law or high levels of corruption, environmental degradation tends to be widespread due to various factors [22,46]. Insufficient enforcement of environmental regulations undermines investments in sustainability and allows harmful practices to continue unchecked [47]. Moreover, corruption can lead to flourishing illegal activities, such as unregulated deforestation, illegal fishing, and pollution from industrial activities, further impeding environmental protection initiatives [48].

Based on numerous empirical research, the existing body of literature consistently demonstrates that effective governance, characterized by transparent decision-making processes, stakeholder participation, and robust regulatory frameworks, plays a crucial role

in promoting positive environmental outcomes. However, a significant knowledge gap remains in understanding the intricate interplay between governance and environmental dimensions, particularly within nations grappling with political instability, corruption, or inadequate institutional capacity. These nations often face challenges such as illegal resource extraction, deforestation, and pollution due to weak enforcement of environmental regulations. These dynamics underscore the necessity for more sophisticated frameworks that comprehensively encapsulate the multifaceted nature of governance, including the role of civil society, the private sector, and international cooperation and its diverse impacts on environmental performance. This comprehensive approach is essential for addressing environmental challenges and achieving sustainable development goals in these contexts.

2.3. National environmental performance

The environmental performance index (EPI) is a valuable tool for evaluating countries' environmental performance by considering indicators related to environmental health, air and water quality, biodiversity, and ecosystem vitality [49]. It is widely utilized to compare countries' environmental policies and performances. However, the EPI's methodology, which condenses multifaceted environmental factors into a single quantitative score, has been criticized due to its potential oversimplification of complex environmental phenomena [49]. While the index's simplicity makes cross-country comparisons more accessible, it also raises concerns about overlooking the nuances of specific environmental issues within individual countries [49].

The environmental performance index (EPI) is a versatile and user-friendly tool that simplifies comparing environmental performance across countries [50]. Its intuitive design and comprehensive data make it particularly valuable for policymakers, researchers, and environmental advocates. This unique feature allows policymakers to pinpoint specific environmental areas that need attention quickly and monitor progress over time, aiding in developing targeted policies and initiatives. Moreover, the biannual reporting, meticulously conducted by Yale University, ensures that the data is regularly updated and incorporates detailed metrics and analysis. This in-depth approach enables international organizations such as the United Nations to monitor and evaluate global sustainability initiatives effectively, providing a foundation for informed decision-making and implementing impactful environmental policies.

On the other hand, critics argue that the environmental performance index (EPI) oversimplifies environmental performance assessment, potentially masking countries' unique and complex environmental challenges [51]. For instance, developing countries may receive low scores on environmental indicators not necessarily due to a lack of effort but because of structural constraints such as limited financial resources or institutional capacity [52]. This introduces biases that may disproportionately favor wealthier nations, whose robust infrastructure and institutions are better equipped to address environmental concerns [49]. Moreover, the epi's reliance on satellite data and composite indicators has been criticized for its limited ability to capture the nuanced complexities at the ground level, particularly in regions with weaker reporting mechanisms [53].

Despite the criticisms of the environmental performance index (epi) for potentially oversimplifying complex environmental issues, its use as an indicator for measuring a country's environmental performance is justified due to its comprehensive and standardized approach [54]. The epi aggregates diverse environmental factors such as air and water quality, biodiversity, and ecosystem vitality into a single score, making cross-country comparisons accessible and actionable [55]. This simplicity is a key advantage for policymakers, enabling them to identify environmental strengths and weaknesses and craft targeted interventions quickly. Additionally, the biannual updates conducted by Yale University ensure that the data is reliable, up-to-date, and reflective of global trends, further solidifying its role as a valuable tool for assessing progress in sustainability efforts. While critics highlight the index's limitations in capturing local complexities, particularly in developing nations, its broad application and regular updates provide a useful foundation for monitoring global environmental performance, offering insights that can guide international environmental policy.

2.4. Institutional theory and governance-environment nexus

The institutional theory provides a valuable framework for examining the intricate relationship between governance and environmental performance. This theory suggests that institutional environments encompass formal rules such as laws and regulations and informal norms like cultural beliefs, which are pivotal in shaping governance mechanisms and determining their effectiveness [56,57]. Robust institutions, characterized by well-established legal frameworks, influential regulatory bodies, and widespread adherence to ethical norms, are generally associated with better governance, heightened transparency, and increased accountability, all vital for preserving the environment [58,59]. Countries with robust institutional frameworks, backed by solid legal enforcement and widespread social acceptance of environmental regulations, are better positioned to implement and enforce environmental policies, ultimately leading to superior environmental outcomes [60].

In countries with weak institutions, ineffective policy implementation, lack of law enforcement, and widespread corruption, governance efforts are often compromised and ineffective [61]. Consequently, well-meaning environmental policies may struggle to translate into tangible action. The literature on institutional theory emphasizes the pivotal role of strong institutions in supporting effective environmental governance, whereas weak institutions are associated with perpetuating environmental degradation [62]. However, this perspective fails to fully acknowledge the intricate and multifaceted interplay between governance structures and environmental performance, which involves complex feedback loops and various influencing factors. This complex interplay can include factors such as political stability, public participation, access to resources, and historical contexts, all contributing to the effectiveness of environmental governance within a given country.

Improving governance through transparent decision-making processes, robust regulatory frameworks, and effective enforcement mechanisms can lead to better environmental outcomes such as reduced pollution, conservation of natural resources, and sustainable development initiatives [10]. Conversely, positive environmental outcomes can also strengthen institutions by reinforcing norms and

fostering a culture of accountability through public participation, environmental education, and promoting eco-friendly policies. On the other hand, poor environmental performance, including high pollution levels, resource depletion, and lack of sustainable practices, can weaken institutions, creating a harmful cycle where governance mechanisms such as regulatory oversight and enforcement deteriorate over time [60]. This reciprocal relationship, which involves the complex interplay between governance, institutional dynamics, and environmental performance, has not been fully explored in the existing literature. This study addresses this gap by examining how public governance impacts environmental performance across different sectors and regions.

The institutional theory helps explain how strong governance can create an environment favorable for both domestic and foreign investment, especially in the sustainability and environmental sectors. The study highlights various aspects of governance, such as regulatory quality, rule of law, and government effectiveness, which all play crucial roles in influencing investment decisions. For example, countries with high regulatory quality attract investments by offering precise and enforceable environmental regulations, thus reducing business uncertainty. Investors prefer countries with predictable and fair regulations, as this minimizes the risks of sudden policy changes or corruption. This is particularly important for environmental investments, which often require long-term commitments.

The rule of law ensures that businesses are held accountable for their environmental impact, which boosts investor confidence, especially for those interested in environmental, social, and governance (ESG) investing. Investors feel more secure in countries where environmental laws are strictly enforced, knowing their investments are protected from legal risks and potential reputational damage. Additionally, government effectiveness is crucial in implementing environmental policies. Countries with effective governance can efficiently execute environmental projects, such as renewable energy initiatives, reducing the likelihood of bureaucratic delays or corruption. This makes it easier for investors to navigate the regulatory landscape.

Another important aspect of governance is the control of corruption. High levels of corruption can increase investment risks, especially in sectors that rely on transparency and fairness, such as environmental protection. Countries with low corruption are considered safer for investment since corruption can undermine the enforcement of environmental laws and governance structures. When governments effectively control corruption, they create a level playing field for investors, particularly those prioritizing long-term sustainability. Additionally, voice and accountability are increasingly important for investors focused on sustainability. Investors are attracted to countries with strong civic participation and accountability, as these reflect a political climate conducive to implementing robust environmental policies. This political will can help attract responsible investment.

Political stability is a cornerstone that significantly mitigates investment risk. A serene and predictable political environment fosters the consistency and reliability of environmental policies, which are vital for the success of long-term investments, particularly in innovative sectors like renewable energy infrastructure projects. In countries marked by political stability, policies remain steadfast and actively champion and sustain sustainable investment practices. This unwavering commitment instills a profound sense of confidence in investors, assuring them of the resilience and longevity of their investment strategies in an ever-evolving global landscape.

2.5. Economic prosperity and environmental performance

Economic prosperity plays a significant role in moderating the relationship between governance and environmental performance. This aligns with the environmental Kuznets curve (EKC) hypothesis, which suggests that environmental quality initially deteriorates with economic growth but eventually improves once a certain level of prosperity is reached [13,63]. The EKC implies that wealthier countries have the financial capacity to implement stricter environmental regulations, invest in cleaner technologies, and enforce policies more effectively than less affluent countries [64]. As a result, they can achieve better environmental performance and mitigate the negative impacts of economic growth on the environment.

The environmental Kuznets curve (EKC) is a widely debated concept in environmental literature. Some scholars argue that the EKC does not universally apply across all environmental indicators or regions. For example, wealthier nations may reduce air pollution by adopting cleaner technologies. However, they often continue to significantly contribute to global environmental degradation through their consumption patterns and outsourcing polluting industries to developing countries [64]. This raises important questions about whether economic growth can truly be decoupled from environmental harm and highlights the need for a more comprehensive understanding of the complexities involved in sustainable development.

This study builds on the EKC hypothesis by examining how economic prosperity amplifies the positive effects of governance on environmental performance. Specifically, it shows that countries with higher GNI per capita experience stronger correlations between governance dimensions such as voice and accountability and environmental outcomes. This finding highlights the importance of economic resources in enabling countries to implement effective governance mechanisms for environmental stewardship. However, it also underscores the need for policies that ensure sustainable and equitable economic growth, particularly in the face of global environmental challenges.

3. Hypothesis development

3.1. Voice and accountability and national environmental performance

Voice and accountability measure the extent to which citizens can participate in governance and protect their freedoms, which has meaningful implications for environmental governance. The theoretical perspectives that connect voice and accountability to environmental performance posit that democratic institutions facilitate the flow of information between citizens and policymakers, which leads to more responsive and responsible management of environmental resources [65]. The accountability mechanisms in

democracies, including free press and civic activism, enable environmental issues to gain prominence in public discourse and policy agendas [66]. Studies conducted by Scruggs [67] and Payne [68] demonstrate that democratic institutions that prioritize voice and accountability are associated with improved environmental performance, such as reduced emissions and sustainable resource management. Theories of "ecological modernization" further support this notion, suggesting that democratic societies with high levels of public participation are more likely to adopt sustainable technologies and policies [69]. When citizens express their concerns and hold governments accountable, it increases transparency and scrutiny over environmental policies, resulting in more sustainable outcomes [70].

H1. voice and accountability are positively associated with national environmental performance

3.2. Political stability and national environmental performance

Political stability is commonly understood as the absence of systemic threats to the current political system, encompassing both the peaceful transfer of power and the government's capacity to manage public affairs effectively. Theoretical discussions often start with the premise that stable governance structures are better positioned to formulate and implement long-term environmental strategies [71]. The argument is that political stability allows for the continuity of policies, accumulation of institutional knowledge, and consistent enforcement of regulations [72]. Conversely, political instability can lead to short-termism in policy orientation, corruption, and a lack of enforcement [73]. Political stability and the absence of violence are signs of a society's freedom from conflict, political turmoil, and violence, which can significantly affect environmental sustainability. A stable political environment often provides the necessary institutional support to establish and enforce robust environmental policies. The ground-breaking study by Li and Reuveny [74] demonstrates that political stability considerably enhances environmental performance, mainly by reducing deforestation and carbon emissions. Stable political conditions enable long-term planning and the allocation of resources to environmental projects. However, the effect of such conditions may not yield immediate results [71].

H2. political stability is positively associated with national environmental performance

3.3. Government effectiveness and national environmental performance

Government effectiveness reflects the quality of public services, the civil service and its independence from political pressures, the quality of policy formulation, and the credibility of the government's commitment to its stated policies [75]. The underlying premise is that effective governments are better equipped to design, implement, and enforce environmental regulations, manage natural resources sustainably, and respond to environmental challenges. Effective governments can mobilize resources for environmental protection, enact and enforce comprehensive environmental legislation, and foster cooperation among various stakeholders. Furthermore, effective governments are also seen as more capable of long-term planning, necessary for addressing environmental issues that often extend beyond electoral cycles. Research findings suggest that well-functioning governments tend to achieve better environmental outcomes [76]. Congleton [77] argues that governance effectiveness is essential for successfully implementing policies aimed at public goods such as environmental sustainability. Similarly, Bättig and Bernauer [78] suggests that effective governance structures can successfully implement strict environmental regulations that are adhered to, leading to better national environmental performance. Governance effectiveness is not only evident in policy formulation but also in enforcement capabilities. Fredriksson and Wollscheid [79] emphasize that an effective governance system can implement and maintain surveillance over environmental regulations.

H3. government effectiveness is positively associated with national environmental performance

3.4. Regulatory quality and national environmental performance

Regulatory quality refers to the government's ability to create and enforce sound policies that facilitate private sector growth [23]. High-quality regulation is characterized by clarity, coherence, and transparency, as well as the ability to adapt to new environmental challenges such as emissions standards, waste management protocols, and conservation efforts. Theoretically, the link between regulatory quality and environmental performance is anchored in the belief that well-designed regulations can effectively control pollution, protect natural resources, and incentivize the private sector to innovate toward sustainability [80]. The regulatory quality also influences the behavior of economic actors and the public's participation in environmental stewardship [81]. Studies have shown a positive correlation between regulatory quality and environmental performance, suggesting that countries with better regulatory frameworks have higher environmental performance. Several empirical studies, including those conducted by Neumayer [31], Fredriksson, Vollebergh [82], highlight the connection between strong environmental regulations and positive environmental outcomes. For instance, countries with well-established regulatory agencies tend to perform better in metrics assessing water quality, air pollution, and biodiversity conservation [83]. Regulatory quality also promotes the uptake of environmental technologies and encourages corporate environmental responsibility [84].

H4. regulatory quality is positively associated with national environmental performance

3.5. Rule of law and national environmental performance

The rule of law, defined as the principle that law should govern a nation, as opposed to being governed by arbitrary decisions of individual government officials, plays a crucial role in shaping environmental outcomes at the national level. The rule of law assesses the level of trust in and adherence to societal rules, which includes the quality of contract enforcement, property rights, and the judiciary [23]. In environmental governance, the rule of law ensures that environmental policies are consistently applied and enforced and that legal frameworks support sustainable practices. A well-functioning rule of law typically fosters better environmental outcomes by consistently applying and enforcing environmental laws and policies. The rule of law is posited to influence environmental performance by providing the legal structures necessary for effective environmental governance. It is theorized that robust legal frameworks underpin the creation and enforcement of environmental regulations, protect property rights, and facilitate the resolution of environmental disputes. The rule of law also strengthens transparency and accountability, providing legal avenues for civil society and environmental organizations to challenge environmentally harmful practices [85]. Studies have found positive correlations between strong rule of law and high environmental performance scores, indicating that countries with well-established legal systems tend to manage their environments better [86].

H5. the rule of law is positively associated with national environmental performance

3.6. Control of corruption and national environmental performance

Corruption control refers to the extent to which public power is exercised for private gain, including petty and grand forms of corruption and "capture" of the state by elites and private interests [23]. Corruption is often cited as a major barrier to effective environmental management, as it can distort policy-making processes, reduce compliance with regulations, and limit the capacity of states to protect natural resources. Theoretically, corruption is seen as a detriment to environmental performance because it undermines regulatory frameworks, decreases the efficiency of public expenditures in environmental projects, and reduces the effectiveness of environmental agencies [87]. Research generally indicates a negative correlation between corruption levels and environmental performance, with higher corruption associated with poorer environmental outcomes [88]. Corruption significantly damages a country's environmental performance by eroding the enforcement of environmental laws and facilitating the illegal exploitation of natural resources [89]. Corruption can adversely affect biodiversity, increasing deforestation rates and species extinction [90]. However, it is essential to note that the relationship between corruption and environmental performance is complex and depends on various contextual factors. This complex relationship can vary based on factors such as the strength of institutions, the level of economic development, and public awareness of environmental issues.

H6. control of corruption is positively associated with national environmental performance

3.7. The moderating role of country economic prosperity

The relationship between the quality of governance and environmental performance has been well documented in the literature. However, the impact of economic prosperity as a moderator on this relationship is not yet fully explored. Gross national income (GNI) per capita is frequently used to measure economic prosperity. It could play a significant role in determining the success of governance in achieving environmental objectives. Economic prosperity can provide the financial resources and technological capabilities necessary for implementing and sustaining environmental policies, potentially enhancing the effect of good governance on environmental performance. Conversely, it is hypothesized that in less prosperous countries, even well-structured governance may struggle to achieve desired environmental outcomes due to resource constraints [30]. Empirical research has demonstrated a positive relationship between governance indicators (such as those provided by the worldwide governance indicators) and environmental performance indices (like the epi). These studies indicate that better governance is associated with better environmental outcomes [24].

The correlation between public governance and national environmental performance has long been a topic of academic interest. As measured using GNI, the country's economic prosperity is a crucial moderating variable in this relationship. According to the environmental Kuznets curve (EKC) theory, a higher GNI per capita is often linked to a shift from industrialization to a service-based economy, generally accompanied by more sustainable practices and increased environmental regulations. This, in turn, can positively impact the environment [91]. Strong public governance can enhance favorable environmental outcomes in such economic contexts by providing the necessary resources and political will to enforce and sustain environmentally beneficial policies [92]. However, in countries with lower GNI per capita, the correlation between governance and environmental performance may be less pronounced or negative. In these situations, even well-designed governance structures may struggle to make a significant impact due to resource constraints and other pressing social needs [30]. Hence, a country's economic prosperity plays a crucial role as a moderating factor, potentially amplifying the positive effects of effective governance in wealthier countries while attenuating or neutralizing them in less affluent nations.

H7. country economic prosperity moderates the relationship between voice and accountability and national environmental performance

H8. country economic prosperity moderates the relationship between political stability and national environmental performance

H9. country economic prosperity moderates the relationship between government effectiveness and national environmental

performance

H10. country economic prosperity moderates the relationship between regulatory quality and national environmental performance

H11. country economic prosperity moderates the relationship between rule of law and national environmental performance

H12. country economic prosperity moderates the relationship between control of corruption and national environmental performance

4. Methodology

4.1. Population, sample, and data

The population under consideration in this study consists of countries that are members of the World Bank. The World Bank has members from various regions, thus providing a comprehensive global analysis landscape. This population includes countries from North America, Western Europe, Central Asia, East Asia and the Pacific, South Asia, the Middle East and North Africa (MENA), Sub-Saharan Africa, Latin America, and the Caribbean. The scope and diversity of this population offer an extensive platform to investigate the relationship between public governance and environmental performance. A sample of countries with a public governance score and an Environmental Performance Index (EPI) score was taken from the defined population. The sample consists of 175 countries that encompass diverse regions and economic conditions. This sample size provides a robust framework for statistical analysis and empirical inference, enhancing the generalizability and reliability of the study's findings. The investigation period spans from 2006 to 2022. However, it is worth noting that the EPI score is released biennially, effectively reducing the number of years for this particular metric to nine. Therefore, the dataset includes data from nine biennial EPI scores. The total dataset utilized in this study consists of 1430 data points.

The chosen period from 2006 to 2022 is significant due to various critical global public governance and environmental policy developments. Numerous international environmental agreements and governance initiatives were established or reinforced during this period. For instance, the 2006 Stern Review emphasized the economic impacts of climate change, prompting many countries to reconsider their environmental policies. This was followed by the 2015 Paris Agreement, a landmark treaty aiming to limit the rise of global temperature, which significantly influenced national environmental performance frameworks. Additionally, the period witnessed the global financial crisis of 2008, which impacted economic prosperity in many countries, leading to shifts in governance priorities, including environmental regulation.

4.2. Research model and analysis

The study proposes two research models (model 1 and model 2). In model 1, the study suggests that the national environmental performance (NEP) is influenced by the components of public governance, including voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. In addition to the proposed model analysis in model 1, the study introduces a model analysis that incorporates interaction with a moderating variable, specifically the country's economic prosperity. Fig. 1 illustrates the research model used to obtain graphic visualization of model analysis as stated in model 1 and model 2.

This study investigates the intricate relationship between public governance and national environmental performance (NEP) through a comprehensive cross-country analysis. Understanding how public governance structures impact national environmental performance is essential, especially in our current context of escalating environmental challenges. To address potential endogeneity concerns, where cause and effect may obscure one another and ensure that our estimates are robust, the study employed the two-stage least squares (2SLS) regression model. The 2SLS model is particularly advantageous as it allows us to control for possible reverse causality, where an effect may seem to influence its cause. Moreover, it mitigates the risks associated with omitted variable bias, which occurs when the analysis does not include key influencing factors. By utilizing carefully selected instrumental variables that correlate with the endogenous explanatory variables yet remain uncorrelated with the error term, the study aims to accurately depict the

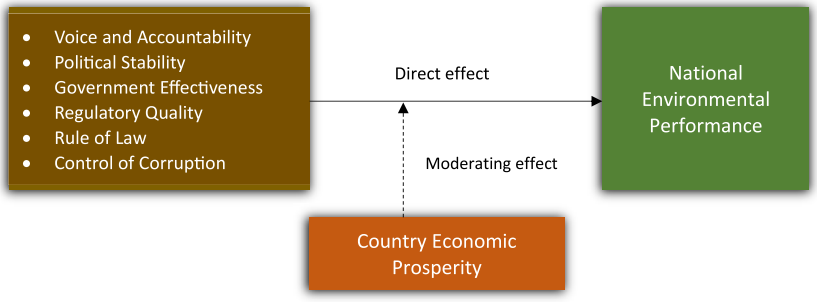

Fig. 1. Research model.

relationship between governance and environmental performance. This nuanced approach strengthens the findings and contributes to the ongoing discourse in environmental governance studies.

4.3. Variable operationalization and measurement

In this study, the environmental performance index (EPI) serves as the key dependent variable, measuring how well countries perform in achieving sustainable environmental practices. In contrast, the independent variables that are examined include dimensions such as voice and accountability reflect the extent to which citizens can participate in the political process; political stability, indicating the likelihood of governmental upheaval; government effectiveness, which assesses the quality of public services and policy implementation; regulatory quality, denoting the ability of the government to formulate and enforce sound policies; rule of law, representing the extent to which laws are enforced fairly; and control of corruption, which evaluates the prevalence of corruption within the government. Additionally, gross national income per capita is identified as a moderating variable, which may influence the relationship between the independent variables and the environmental performance index. A comprehensive overview of these variables is displayed in Table 1, allowing for a clearer understanding of their roles in this study.

5. Results

5.1. Descriptive statistics

Table 2 provides a detailed national environmental performance (NEP) analysis across national income categories. The high-income country category has a mean nep of 70.5, showing wealth is usually associated with better environmental performance. This could be due to improved infrastructure, advanced technology, effective policies, or a combination of these factors. On the other hand, the low-income country category has a mean of 42.8, indicating that these nations face multiple challenges in balancing development and environmental protection. Interestingly, the lower-middle and upper-middle-income countries have mean scores of 49.6 and 61.2, respectively, indicating an incremental increase in environmental performance in line with economic growth.

Table 3 details the average public governance scores based on the country's economic prosperity. The table indicates a clear correlation between higher income and better governance scores. High-income countries consistently score better across all governance metrics, reflecting a more advanced and well-established governance system. For instance, high-income countries achieve an impressive government effectiveness score of 84.9, indicating efficient public services, sound bureaucratic processes, and autonomous functioning of public entities. Similarly, the rule of law and control of corruption scores (84.8 and 84.4, respectively) demonstrate strict legal frameworks and robust measures against corrupt practices.

On the other hand, countries with low incomes exhibit comparatively lower scores for governance metrics, highlighting the hurdles and scope for enhancement in their governance infrastructure. For example, the score for voice and accountability is 24.1, indicating the possibility of limited civil liberties, restrictions on freedom of speech, or issues in participatory governance. The government effectiveness score for this category is 17.1, implying potential inefficiencies or difficulties in public administration and service delivery.

There is a clear difference in the quality of governance between lower-middle-income countries and upper-middle-income countries. The upper-middle-income countries display a better regulatory environment, with a regulatory quality score of 53.4, while the lower-middle-income countries score only 36.0. This suggests that the upper middle-income countries have a more structured and effective regulatory system, indicating a progression in governance metrics consistent with their economic growth.

Fig. 2 provides a scatterplot to visualize the relationship between national environmental performance (NEP) and public governance based on the country's economic prosperity (income category). The scatterplots comparing five governance indicators (voice and accountability, political stability, government effectiveness, regulatory quality, and control of corruption) with national environmental performance (NEP) reveal correlations that vary depending on income classification. A preliminary visual assessment indicates a positive association between these governance metrics and NEP scores, particularly pronounced within higher income categories. This trend suggests that robust governance frameworks, characterized by greater accountability, political stability,

Table 1
Variable operationalization.

Variable	Function	Variable operationalization	Scale
National environmental performance	Dependent variable	Environmental performance index published by Yale center for environmental law & policy.	Ratio, 0–100, the higher the index the better environmental performance
Voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, Control of corruption	Independent variable	World governance indicators score published by the world bank organization	Ratio, 0–100, the higher the index the better the performance of public governance
Country economic prosperity	Moderating variable	Classification of income per capita into low income, lower middle income, upper middle income, and high income following the world bank organization measured based on gross national income (GNI) per capita	Nominal

Table 2
Nep by country economic prosperity (source: data processed).

Country income category	National environmental performance (NEP)			
	High income country	Low-income country	Lower middle-income country	Upper middle-income country
Valid data	318	260	404	447
Mean	70.5	42.8	49.6	61.2
Std. Deviation	12.9	11.0	14.0	13.6
Minimum	30.7	18.4	18.9	26.3
Maximum	95.5	73.1	95.5	90.5

Table 3
Average public governance score by country economic prosperity (source: data processed).

Public governance	Low-income country	Lower middle-income country	Upper middle-income country	High income country
Voice and accountability	24.1	36.3	50.1	74.8
Political stability	23.8	32.0	49.2	72.3
Government effectiveness	17.1	33.9	54.4	84.9
Regulatory quality	20.5	36.0	53.4	83.4
Rule of law	19.9	32.4	49.3	84.8
Control corruption	21.5	32.2	49.1	84.4

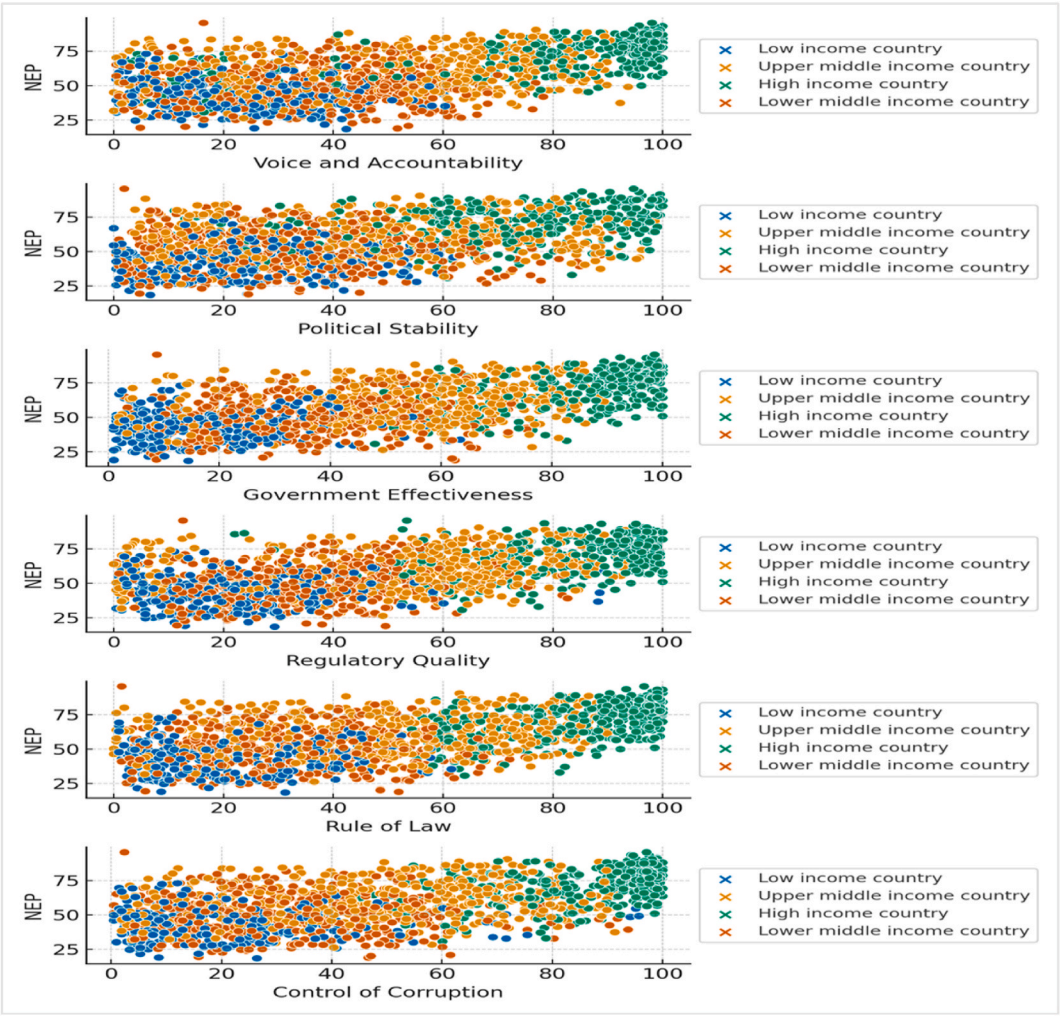

Fig. 2. Scatter plot of the relationship of public governance and NEP (source: data processed).

effectiveness, regulatory quality, and lower corruption levels, may foster enhanced environmental outcomes.

Notably, high-income nations typically exhibit a confluence of high governance scores and nep, insinuating that financial prosperity potentially facilitates better environmental stewardship through more efficient governance structures. Conversely, the scatterplots reveal a more significant variance in NEP scores among lower-income nations, highlighting a multifaceted relationship between governance and environmental performance that transcends economic wealth. Outliers within the data warrant further scrutiny, as they may represent unique cases where governance and environmental performance deviate from the observed broader trends. The consistency of these patterns across all governance indicators reinforces the potential significance of robust institutional frameworks in achieving superior environmental performance.

5.2. Trend analysis

The comprehensive examination of trends within the combined dataset offers profound insights into the changing dynamics of various performance indicators across all countries over time. Each indicator is a distinct lens through which to observe and evaluate global governance, environmental sustainability, and institutional quality. The national environmental performance metric reflects countries' efforts in maintaining environmental sustainability. The trend analysis (Fig. 3) shows moderate fluctuations across the years, indicating varying levels of commitment and success in addressing environmental issues. While a general upward trend suggests improvements, some periods exhibit stagnation or minor declines, signaling uneven progress across different regions and periods. The overall message is that environmental performance is gradually improving, though not uniformly.

Voice and accountability are essential indicators that assess the degree to which citizens are empowered to participate in the selection of their government and exercise their rights to freedom of expression and access to media. The data suggests that there has been minimal fluctuation in these measures over the years, indicating that while there hasn't been a significant deterioration in democratic freedoms and participation rights on a global scale, there also hasn't been a substantial advancement in expanding these liberties. This stability in the assessment of voice and accountability reflects both the incremental progress and the constraints in the evolution of democratic systems worldwide.

Throughout the analyzed period, the indicator of political stability, which assesses the likelihood of political unrest, violence, or terrorism, displays significant fluctuations. These fluctuations are marked by clear periods of decline, which can be attributed to global conflicts, political crises, or economic downturns. This indicator reflects the dynamic and often volatile nature of global political stability, where major global events such as wars or political uprisings can profoundly impact overall trends. While there are instances of improvement in certain years, the data indicates persistent global challenges in maintaining political stability.

Over time, the measure of government effectiveness, which encompasses the quality of public services, the formulation of policies, and the government's commitment to policy implementation, has exhibited a consistent and positive trajectory. This suggests that, on a global scale, countries have made significant strides in enhancing their governance structures, resulting in improved public services

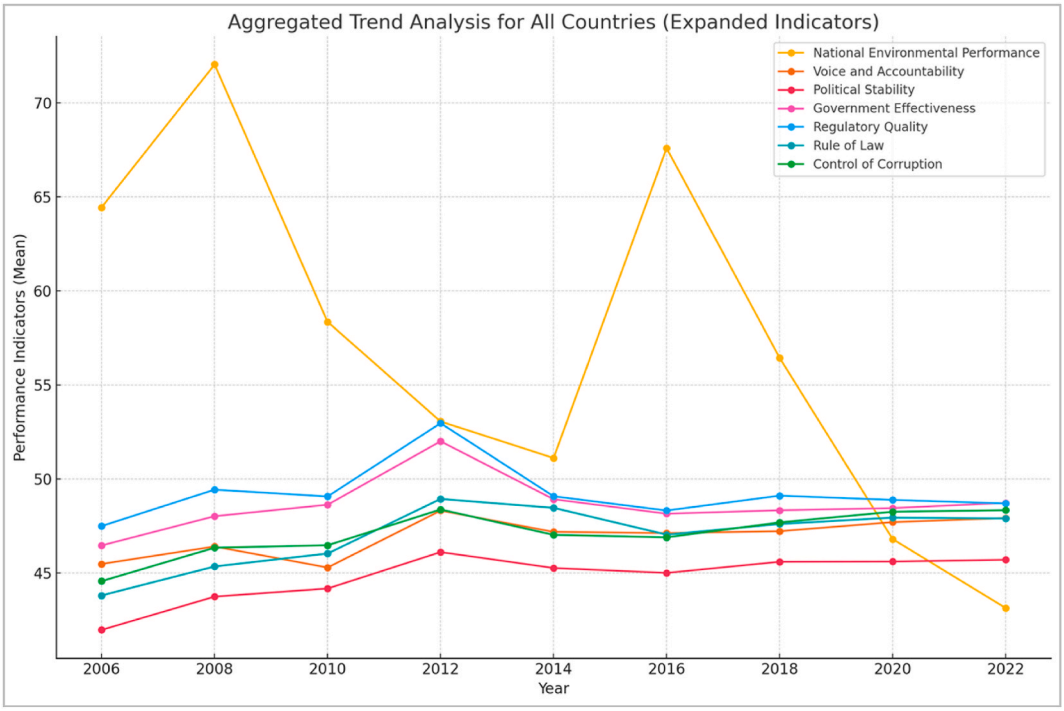

Fig. 3. Trend chart of public governance and NEP (source: data processed).

and the formulation of more impactful policies. Despite occasional minor downturns during specific periods, the overarching trend indicates a gradual and sustained strengthening of governmental capacity worldwide.

The assessment of regulatory quality, which evaluates the capacity of governments to establish and uphold regulations that support development, has exhibited consistent enhancement over the years. This suggests a concerted global endeavor to foster improved business, trade, and governance policy environments. The upward trajectory of this indicator signifies advancements in governance reforms targeting the enhancement of market conditions and regulatory frameworks, reflecting a commitment to creating more favorable conditions for economic growth and stability.

The indicator assessing the rule of law measures the extent to which legal systems are respected and enforced. Currently, it is showing a promising upward trajectory, indicating positive developments. This suggests a growing commitment across various countries to fortify their legal frameworks. It also reflects an increasing global trust in the effectiveness of judicial systems and law enforcement, even though certain areas and periods face significant challenges.

The control of corruption indicator is a measure that assesses the degree to which public power is utilized for private gain, providing a comprehensive overview of the prevalence of corruption. This indicator reveals a complex and nuanced landscape, with certain periods showing advancements in combating corruption. In contrast, others demonstrate little to no progress or even regression, underscoring the persistent global struggle against corrupt practices. Despite concerted efforts to enhance transparency and diminish corruption, there have been notable achievements in specific regions. Yet, formidable challenges persist, as evidenced by the uneven nature of progress indicated by the data.

Analyzing current trends provides a nuanced yet hopeful insight into global governance and institutional performance. Key indicators such as government effectiveness, regulatory quality, and adherence to the rule of law are steadily improving. However, the metrics for political stability and control of corruption reveal a more uncertain and changeable landscape, highlighting persistent global challenges. The comprehensive data indicates advancements and areas necessitating additional focus to cultivate more robust, transparent, and efficient governance worldwide.

5.3. Direct effect analysis

Table 4 showcases the complex connection between public governance and national environmental performance (NEP). We can address endogeneity by employing an instrumental-variables two-stage least squares (2SLS) regression model, resulting in more dependable estimates of governance indicators' direct effects on NEP. Regulatory quality was considered an endogenous variable, while the year of data served as an instrumental variable.

The coefficient for voice and accountability is −1.609, with a statistically significant p-value of 0.043, indicating that higher voice and accountability are associated with decreased environmental performance. This negative relationship suggests that in some contexts, democratic governance, which prioritizes public participation and freedom of expression, may inadvertently result in weaker environmental outcomes. One possible explanation is that democratic systems often face pressures to prioritize economic growth and other immediate concerns, which can lead to trade-offs with long-term environmental goals. In lower-income or developing countries, the push for short-term economic benefits might outweigh considerations for environmental sustainability, resulting in this observed negative relationship.

Political stability shows a positive and statistically significant relationship with nep, as reflected by a coefficient of 0.651 (p-value = 0.036). This indicates that more politically stable countries tend to have better environmental performance. Political stability can create a conducive environment for implementing and enforcing environmental policies, as stable governments are better positioned to plan and execute long-term environmental strategies without the disruptions caused by political unrest. Additionally, stable governments are more likely to be consistent in their regulatory approach, fostering an environment where sustainability can flourish.

The relationship between government effectiveness and nep is negative, with a coefficient of −5.038 and a p-value of 0.042, making it statistically significant. This result suggests that more effective governments may be associated with lower environmental performance, which might seem counterintuitive. One explanation for this outcome could be that, in certain contexts, highly effective governments might focus on rapid economic development or industrialization to meet growth objectives, often at the expense of

Table 4
The direct effect of public governance on NEP.

Model analysis	Two stage least square (2SLS) regression			
Dependent variable	National environmental performance (nep)			
Statistics	Coefficient	Robust std error	Z-statistics	P-values
Voice and accountability	−1.609	0.795	−2.02	0.043
Political stability	0.651	0.309	2.10	0.036
Government effectiveness	−5.038	2.478	−2.03	0.042
Regulatory quality	10.489	4.779	2.19	0.028
Rule of law	−5.117	2.321	−2.20	0.028
Control corruption	1.544	0.826	1.87	0.062
Number of observations	1431			
Wald chi squared	17.63			
Probability	0.007			
Root mean squared error (RMSE)	107.79			

environmental protection. In nations where economic development takes precedence, government effectiveness may be directed into policies that promote industrial expansion, infrastructure development, or resource extraction, all of which can negatively impact environmental performance.

Regulatory quality shows a strong positive relationship with nep, with a coefficient of 10.489 and a p-value of 0.028. This significant positive effect suggests that higher regulatory quality directly enhances environmental performance. Countries with well-designed, well-enforced regulations are better equipped to address environmental challenges through stringent environmental laws and policies. Regulatory quality reflects the government's ability to craft and implement sound policies, and this result highlights the importance of regulatory frameworks in ensuring environmental sustainability. In this context, regulatory quality is crucial for managing pollution, conserving natural resources, and ensuring compliance with environmental standards.

The relationship between the rule of law and nep is negative, with a coefficient of −5.117 and a p-value of 0.028, making it statistically significant. This suggests that a more vital rule of law may have a detrimental effect on environmental performance in certain contexts. One possible explanation is that enforcing property rights and legal systems, particularly in developing countries, may prioritize economic stability and the protection of business interests, potentially at the expense of environmental regulations. In some countries, the rule of law might facilitate resource exploitation and industrial activities that negatively impact environmental sustainability.

The coefficient for control of corruption is positive (1.544), though it is marginally insignificant at the 0.05 level (p-value = 0.062). This suggests that reducing corruption improves environmental performance, but the effect is not as robust in this model. Corruption undermines public governance effectiveness, often leading to weak enforcement of environmental regulations, misallocating resources, and perpetuating environmentally harmful practices. Countries with lower levels of corruption are generally better equipped to implement and maintain effective environmental protection measures, as decision-making processes are more transparent and less influenced by vested interests.

The Wald chi-squared statistic, calculated at 17.63 with a p-value of 0.007, confirms the model's overall fit within the study context. This statistic indicates that the public governance indicators play a significant role in explaining the variations observed in the NEP. Furthermore, the root mean squared error (RMSE), which stands at 107.79, highlights that while the model does account for some level of variation in environmental performance, there is still considerable scope for enhancement. This ongoing variability could likely be attributed to the influence of other factors or variables in the environment but was not integrated into the current analysis, suggesting that future research could benefit from exploring these additional elements for a more comprehensive understanding.

The results demonstrate that public governance plays a complex and multifaceted role in determining environmental outcomes. While some governance indicators, like regulatory quality and political stability, directly improve environmental performance, others, such as government effectiveness and the rule of law, show adverse effects, likely due to trade-offs between economic growth and environmental sustainability. These findings underscore the need for policymakers to carefully consider the broader implications of governance reforms on environmental performance, particularly in contexts where economic and environmental goals may conflict. Table 5 presents a summary of the conclusion on the hypotheses.

5.4. Moderating effect analysis

The regression analysis in Table 6 offers a comprehensive view of how different aspects of governance influence national environmental performance (NEP) and how these relationships are moderated by the level of economic prosperity measured by gross national income (GNI). The interaction between GNI and public governance indicators reveals crucial insights into how economic prosperity moderates the impact of public governance on national environmental performance. As countries become wealthier, their governance structures tend to function more effectively in promoting better environmental outcomes. However, this relationship is nuanced, with some governance factors becoming more beneficial with higher GNI, while others show diminishing returns as economic development increases.

The interaction term for voice and accountability and GNI is positive (0.678, p = 0.000), indicating that the relationship between voice and accountability and environmental performance improves as national income rises. This suggests that in wealthier countries,

Table 5
Hypothesis conclusion – direct effect.

Hypothesis statement	Expected coef sign	Result coef. Sign	P-value	Conclusion on hypothesis
Voice and accountability are positively linked to the national environmental performance (H1)	+	–	0.043	Rejected
Political stability is positively linked to the national environmental performance (H2)	+	+	0.036	Supported
Government effectiveness is positively linked to the national environmental performance (H3)	+	–	0.042	Rejected
Regulatory quality is positively linked to the national environmental performance (H4)	+	+	0.028	Supported
Rule of law is positively linked to the national environmental performance (H5)	+	–	0.028	Rejected
Control of corruption is positively linked to the national environmental performance (H6)	+	–	0.446	Rejected

Table 6
Regression analysis output - moderating effect.

Model analysis	Two stage least square (2SLS) regression			
Dependent variable	National environmental performance (NEP)			
Statistics	Coefficient	Robust std error	Z-statistics	P-values
Voice and accountability	−2.331	0.708	−3.29	0.001
Political stability	1.432	0.457	3.13	0.002
Government effectiveness	−7.381	1.801	−4.10	0.000
Regulatory quality	15.179	3.714	4.09	0.000
Rule of law	−5.358	1.627	−3.29	0.001
Control corruption	−0.066	0.490	−0.13	0.893
Gross national income (GNI)	22.725	5.443	4.17	0.000
Voice and accountability*GNI	0.678	0.193	3.50	0.000
Political stability*GNI	−0.430	0.149	−2.88	0.004
Government effectiveness*GNI	2.415	0.609	3.96	0.000
Regulatory quality*GNI	−5.113	1.323	−3.86	0.000
Rule of law*GNI	2.022	0.680	2.97	0.003
Control corruption*GNI	0.042	0.175	0.24	0.809
Number of observations	1431			
Wald chi squared	151.42			
Probability	0.0000			
Root mean squared error (RMSE)	53.41			

mechanisms of voice and accountability, such as greater political freedoms, public participation, and transparency, may be more effectively harnessed to promote environmental sustainability. Due to limited resources or weaker institutional capacities, these mechanisms may not have the same impact in lower-income countries. Thus, the positive interaction reflects that higher GNI can amplify the benefits of a governance framework that encourages public accountability, making it more conducive to environmental progress.

The interaction between political stability and GNI is negative (−0.430, $p = 0.004$), suggesting that as national income increases, the positive impact of political stability on environmental performance diminishes. This could imply that while political stability is generally beneficial for environmental governance in lower-income countries, perhaps by providing a secure environment for long-term policy implementation, its relative importance decreases in wealthier nations, where other factors, such as economic interests or governance complexity, may play a more dominant role in shaping environmental outcomes.

The interaction term for government effectiveness and GNI is strongly positive (2.415, $p = 0.000$), meaning that the negative effect of government effectiveness on environmental performance is mitigated as national income rises. In wealthier countries, the resources and capacity to implement policies and deliver public services more effectively can help counterbalance the potential environmental drawbacks of an overly technocratic or efficiency-driven governance model. This positive interaction highlights that wealthier nations can better leverage effective governance structures to integrate environmental concerns into their broader policy frameworks.

The interaction between regulatory quality and GNI is negative (−5.113, $p = 0.000$), indicating that the positive impact of regulatory quality on environmental performance weakens in countries with higher GNI. This could reflect the challenges in wealthier nations, where economic activities become more complex, and regulations may struggle to keep up with industrial growth or environmental degradation. In such contexts, even robust regulatory frameworks may face difficulties maintaining their positive influence on environmental performance and reducing the effect.

The interaction term between the rule of law and GNI is positive (2.022, $p = 0.003$), suggesting that the rule of law's negative effect on environmental performance diminishes in higher-income countries. This could indicate that wealthier nations have the institutional

Table 7
Hypothesis conclusion – moderating effect.

Hypothesis statement	Expected Coef. Sign	Result Coef. Sign	P-value	Conclusion on hypothesis
Country economic prosperity positively moderates the relationship between voice and accountability and national environmental performance (H7)	+	+	0.000	Supported
Country economic prosperity positively moderates the relationship between political stability and the national environmental performance (H8)	+	–	0.004	Rejected
Country economic prosperity positively moderates the relationship between government effectiveness and the national environmental performance (H9)	+	+	0.000	Supported
Country economic prosperity positively moderates the relationship between regulatory quality and the national environmental performance (H10)	+	–	0.000	Rejected
Country economic prosperity positively moderates the relationship between the rule of law and the national environmental performance (H11)	+	+	0.003	Supported
Country economic prosperity positively moderates the relationship between control of corruption and the national environmental performance (H12)	+	+	0.809	Rejected

capacity to enforce environmental regulations more effectively, making the rule of law a valuable tool for improving environmental outcomes. In contrast, in lower-income countries, the rule of law may not have as strong an effect due to weaker institutional frameworks or less effective enforcement mechanisms.

The interaction between control of corruption and GNI is insignificant (0.042, $p = 0.809$), meaning that the effect of controlling corruption on environmental performance is not significantly moderated by national income. This suggests that the impact of corruption control on environmental outcomes does not vary substantially between higher and lower-income countries, indicating that the influence of corruption control may be weak or that other factors play a more prominent role in determining environmental performance.

GNI moderates the complex relationship between public governance indicators and environmental performance. While certain public governance factors become more beneficial with higher national income, others lose their positive influence as countries grow wealthier. This highlights the evolving governance dynamics that shape environmental outcomes across different income levels. Table 7 summarizes the hypothesis conclusion.

6. Discussion

6.1. Discussion on the direct effect of public governance

The finding that voice and accountability are negatively linked to national environmental performance challenges conventional expectations, as voice and accountability, typically associated with democratic governance and civil liberties, are often presumed to foster better environmental outcomes through public participation, transparency, and institutional checks. However, the negative relationship suggests that promoting voice and accountability in some contexts may inadvertently slow environmental progress. This could be due to political pluralism leading to conflicting priorities, policy gridlock, or a higher focus on immediate social and economic concerns over long-term environmental goals. Furthermore, stronger democratic processes may empower industries or interest groups that oppose stringent environmental regulations, prioritizing economic growth over sustainability. This underscores the complexity of governance-environment dynamics and suggests that voice and accountability alone may not guarantee better environmental performance without complementary policies, such as robust environmental regulations or economic incentives aligned with sustainable development.

This study's results show a strong positive correlation between political stability and national environmental performance. This finding supports the notion that stable political environments are essential for creating and implementing effective environmental policies. Political stability is characterized by the absence of violence or terrorism, the strength and continuity of political institutions, and the rule of law. It is widely recognized as a critical factor for economic development and effective governance [93]. The study suggests that a stable political environment allows for developing, implementing, and maintaining long-term environmental strategies without disrupting political turmoil or policy reversals. Empirical research in political ecology and environmental economics suggests that stable governments have the capacity and the continuity to invest in and enforce regulations that lead to better environmental outcomes [31,94]. Improved political stability can increase a state's ability to allocate resources towards environmental protection and participation in international environmental agreements, thus improving its national environmental performance [95]. Moreover, investor confidence in green technologies can be enhanced by stable political systems, attracting investment in sustainable infrastructure, and improving environmental performance [74]. Conversely, political instability can lead to short-sighted policies, neglect of public goods, and weakened environmental protection institutions.

The finding that government effectiveness is negatively linked to national environmental performance presents an intriguing paradox, as government effectiveness typically reflects the quality of public services, policy formulation, and implementation, all of which are presumed to influence environmental outcomes positively. This negative relationship suggests that governments more effective at delivering services and maintaining infrastructure in certain contexts may prioritize economic growth and industrial development over environmental sustainability. Effective governments might implement policies focusing on short-term economic gains, such as expanding industrial production, infrastructure development, or resource extraction, which can lead to environmental degradation if sustainability is not a central focus. Additionally, in countries with high government effectiveness, policy priorities may lean towards economic efficiency and deregulation, which can weaken environmental protections. While government effectiveness is critical for policy success, it does not automatically translate into positive environmental outcomes unless environmental considerations are integrated explicitly into the policy agenda. Therefore, this finding highlights the need for governments to balance effectiveness in governance with a strong commitment to environmental protection and sustainability goals.

The positive association between regulatory quality and national environmental performance reflects a multifaceted dynamic. Governments that establish clear, consistent, and transparent regulations create an enabling environment for compliance and innovation [24]. In such contexts, regulations are not seen as burdensome but as signals that guide the private sector toward sustainable practices [30]. Regulatory quality may also induce compliance through innovation. Stringent but flexible regulations can stimulate technological innovation, leading to cleaner production processes and products [96]. This "innovation offset" effect suggests that the costs of compliance can be mitigated or even outweighed by the benefits of innovation. Voluntary environmental programs, often seen as a complement to regulatory quality, can significantly improve national environmental performance [84]. By participating in these programs, firms can demonstrate environmental stewardship, which can be both a direct response to and a catalyst for enhanced regulatory quality. Empirically, a robust regulatory framework is linked with higher scores in the environmental performance index [97], indicating that countries with better regulatory quality tend to have better environmental outcomes. According to a recent finding, investing in regulatory quality can effectively improve the environment. This has important implications for policymakers.

The research suggests that sound environmental regulations are a critical component of sustainable development, as there is a positive link between regulatory quality and national environmental performance. To achieve significant environmental benefits, it is essential to effectively implement and enforce these regulations and adopt voluntary environmental programs.

A negative link between the rule of law and national environmental performance contradicts expectations of a positive relationship. The hypothesis was that more robust legal frameworks and governance would improve environmental outcomes. A robust rule of law was believed to enhance the implementation of regulations, prevent illegal activities, and increase accountability for environmental damage. This unexpected finding suggests a more complex relationship between governance structures and environmental results. One reason could be that strong legal systems support large-scale projects with significant environmental impacts, which may thrive even as they comply with the law. Environmental harm can occur if regulations are too lenient or economic growth overshadows ecological concerns. This dynamic is especially pertinent in rapidly industrializing countries, where legal frameworks may prioritize economic development over environmental protection. In some nations, a strong rule of law may protect elites or industries with harmful environmental practices, legitimizing actions that compromise sustainability. This finding necessitates a deeper understanding of how governance interacts with environmental performance, highlighting that strong legal systems do not ensure positive ecological outcomes. It is essential to examine the specific laws, their alignment with environmental goals, and broader socio-economic priorities.

6.2. Discussion on the moderating effect of the country's economic prosperity

The study's findings on the effect of economic prosperity, particularly GNI, on voice and accountability and environmental performance have significant implications across national contexts. In wealthier countries, where GNI is high, voice and accountability, measured by citizens' ability to participate in government decisions, are crucial for shaping environmental performance. This indicates a closer alignment between environmental policy and public concerns in prosperous nations, where resources enable greater civic engagement. Thus, fostering civic involvement and strengthening democracy could enhance environmental outcomes. For example, in countries like Norway and Germany, high GNI alongside strong democratic institutions may lead to improved environmental performance through increased public participation in sustainability decision-making. Conversely, in nations with lower GNI, the influence of voice and accountability is weaker, suggesting limited environmental impact due to fewer economic resources. In developing regions such as Sub-Saharan Africa or Southeast Asia, reforms focused solely on voice and accountability may not deliver significant environmental gains without concurrent economic development initiatives providing essential infrastructure and funding. Therefore, policymakers should prioritize integrating governance reforms with economic strategies for sustainable development, emphasizing a cohesive approach where economic growth and governance improvements foster better environmental results.

The finding that a country's economic prosperity positively moderates the relationship between government effectiveness and national environmental performance highlights the crucial role of economic resources in translating government effectiveness into better environmental outcomes. In wealthier countries, higher levels of economic prosperity provide the financial capacity needed to invest in sustainable infrastructure, environmental technologies, and regulatory frameworks that can mitigate the negative environmental impacts of development. Prosperous economies are better positioned to allocate resources toward long-term environmental goals, such as reducing emissions, preserving biodiversity, and transitioning to renewable energy, which can offset the potential trade-offs between economic growth and environmental protection. Additionally, affluent societies may have a more robust public demand for environmental quality, pushing governments to implement more effective environmental policies. Thus, economic prosperity enhances the ability of effective governments to implement comprehensive environmental strategies, ensuring that governance effectiveness is not solely focused on economic growth but also integrates sustainability. This finding suggests that economic prosperity is critical in aligning government effectiveness with environmental goals, underscoring the importance of wealth in supporting sustainable development.

The finding that a country's economic prosperity positively moderates the relationship between the rule of law and national environmental performance underscores how economic resources can strengthen the capacity of legal systems to promote environmental sustainability. In countries with strong economic prosperity, enforcing laws, including environmental regulations, tends to be more robust, as financial resources enable better implementation, monitoring, and compliance mechanisms. Wealthier nations can afford to support judicial systems, environmental agencies, and regulatory bodies, ensuring that legal frameworks are not only in place but also effectively upheld. Additionally, in prosperous economies, businesses and citizens are more likely to comply with environmental laws due to increased public awareness, greater access to environmentally friendly technologies, and the ability to bear compliance costs. This creates a reinforcing cycle where the rule of law and economic prosperity work together to improve environmental performance. As a result, in economically prosperous countries, the rule of law becomes a more potent tool for achieving environmental objectives, ensuring that legal environmental protections are more than just formalities but are actively enforced and adhered to.

6.3. Findings and their relation to the body of knowledge

The findings of this study contribute to the broader body of knowledge on governance and environmental performance by revealing complex and sometimes paradoxical relationships between various dimensions of governance and national environmental outcomes. Notably, the negative relationship between voice and accountability and national environmental performance challenges the conventional wisdom that democratic processes and public participation naturally lead to better environmental results. This suggests that in certain contexts, democratic pluralism may create policy gridlock or enable influential groups that oppose stringent environmental regulations, thus slowing environmental progress. These results add to the emerging literature that emphasizes the importance of

contextualizing democratic governance within the broader economic and institutional environment, showing that democratic governance alone may not guarantee positive environmental outcomes without complementary policies such as strict environmental regulations and economic incentives for sustainability.

The study also highlights the positive correlation between political stability and national environmental performance, reinforcing existing theories in political ecology and environmental economics that stress the importance of stable political systems in creating and sustaining effective environmental policies. This finding underscores that political continuity and institutional strength are crucial for developing and implementing long-term environmental strategies, enabling governments to allocate resources toward environmental protection and participate in international environmental agreements. This confirms previous research, suggesting that politically stable governments have the capacity and continuity to enforce regulations that lead to better environmental outcomes and attract investment in green technologies, further enhancing environmental performance.

Furthermore, the study's finding of a negative relationship between government effectiveness and national environmental performance introduces a new layer of complexity to the governance-environment nexus. While government effectiveness is typically associated with high-quality public services and efficient policy implementation, the results suggest that, in certain contexts, effective governance may prioritize short-term economic growth, often at the expense of environmental sustainability. This highlights the need for policy agendas to balance economic efficiency with sustainability goals, contributing to the discourse on the trade-offs between economic development and environmental protection. This finding aligns with research that calls for integrating environmental considerations into governance effectiveness to achieve sustainable development outcomes.

The positive association between regulatory quality and national environmental performance supports the growing consensus in environmental economics that clear, consistent, and transparent regulations are key drivers of compliance and innovation. This finding contributes to the literature on the role of regulatory frameworks in fostering sustainable development by showing that countries with robust regulatory environments tend to experience better environmental outcomes. The study's results also resonate with the "innovation offset" theory, suggesting that stringent but flexible regulations can stimulate technological innovation, leading to cleaner production processes and improved environmental performance. This aligns with previous research emphasizing the importance of regulatory quality in achieving national and global sustainability goals.

Additionally, the surprising negative link between the rule of law and national environmental performance challenges traditional assumptions that more robust legal frameworks automatically lead to better environmental outcomes. The findings suggest that robust legal systems, particularly in rapidly industrializing countries, may facilitate economic activities with significant environmental impacts if environmental regulations are not adequately integrated into the legal framework. This adds nuance to understanding how governance structures influence environmental outcomes, indicating that strong legal systems are insufficient without a firm commitment to environmental goals. This contributes to a broader discourse on the need to critically examine the content of legal frameworks and their alignment with environmental sustainability.

The study also contributes to the literature on the moderating role of economic prosperity, particularly gross national income (GNI), in shaping the relationship between governance and environmental performance. The results demonstrate that higher levels of economic prosperity in wealthier countries strengthen the positive effects of government effectiveness and the rule of law on environmental outcomes. This highlights the importance of financial resources in supporting sustainable infrastructure, environmental technologies, and effective legal enforcement, confirming the critical role of economic prosperity in aligning governance effectiveness with environmental goals. These findings support existing research on the environmental Kuznets curve (EKC) hypothesis, which posits that environmental quality tends to improve as nations reach higher levels of economic development. However, the results also suggest that in countries with lower GNI, the benefits of governance improvements on environmental outcomes may be limited without concurrent economic development. This emphasizes the need for a cohesive policy approach integrating economic growth with governance reforms to achieve sustainable development.

7. Conclusion

This comprehensive study provides profound insights into the complex and multifaceted relationship between public governance and national environmental performance across various countries. It unveils anticipated trends and unexpected outcomes, enriching our understanding of this dynamic interplay. The findings elucidate that several governance dimensions, such as the degree of public voice and accountability, the level of political stability, the effectiveness of governmental institutions, the quality of regulatory frameworks, and adherence to the rule of law, interact nuanced ways with various national environmental outcomes. This underscores the critical importance of contextual factors, which play a pivotal role in shaping these intricate interactions and ultimately influence environmental performance on a national scale.

The negative association between voice and accountability and environmental performance highlights the potential for democratic pluralism to hinder environmental progress, particularly in contexts where competing interests and policy gridlock impede the adoption of stringent environmental regulations. This finding suggests that while public participation and accountability are essential for inclusive governance, their influence on environmental performance may be contingent on complementary policies prioritizing sustainability. Similarly, the negative relationship between government effectiveness and environmental outcomes calls into question the assumption that effective governance automatically leads to environmental protection, indicating that economic priorities may overshadow environmental goals if sustainability is not integrated into the policy agenda in certain contexts.

Conversely, the strong positive association between political stability and environmental performance reinforces the critical role of stable political systems in fostering long-term environmental policies. Stable governments are more likely to enforce environmental regulations, invest in green technologies, and participate in international environmental agreements, collectively contributing to

improved environmental outcomes. The positive relationship between regulatory quality and environmental performance further emphasizes the importance of clear, consistent, and transparent regulations in promoting compliance and innovation, highlighting the role of regulatory frameworks in driving sustainable development.

The unexpected inverse relationship between the rule of law and environmental performance fundamentally challenges the conventional beliefs surrounding governance practices. It implies that even well-established legal systems can inadvertently promote environmentally destructive economic activities when lacking robust environmental regulations. This revelation necessitates a deeper and more critical analysis of the specific content and objectives embedded within legal frameworks, emphasizing the need for alignment with goals aimed at achieving environmental sustainability.

Moreover, the moderating effect of economic prosperity on the relationship between governance and environmental performance underscores the importance of financial resources in achieving sustainable development. In wealthier countries, economic prosperity enhances the ability of governments to implement effective environmental policies, translating governance improvements into tangible environmental outcomes. This highlights the importance of integrating economic strategies with governance reforms, particularly in lower-income countries where economic constraints may limit the impact of governance on environmental performance.

This study demonstrates that public governance alone does not guarantee better environmental outcomes. Instead, the relationship between governance and environmental performance is highly contextual, shaped by economic, political, and institutional factors. Policymakers should take a holistic approach, balancing governance reforms with economic development strategies and ensuring environmental sustainability is a central focus of governance efforts. Further research is needed to explore these dynamics in different regional and socio-economic contexts and the role of specific governance interventions in promoting sustainable development across diverse settings.

8. Policy implications

The findings of this study carry several important policy implications for governments seeking to enhance national environmental performance through improved governance structures. Firstly, the negative relationship between voice and accountability and environmental performance suggests that policymakers should be cautious in assuming that democratic governance and public participation automatically lead to better environmental outcomes. Political pluralism and competing interests may delay or dilute environmental policies in some contexts. To mitigate these effects, governments should consider designing participatory mechanisms that prioritize long-term environmental goals while managing the potential for policy gridlock. For instance, creating specialized environmental councils or task forces that include diverse stakeholders but focus on consensus-driven, evidence-based decision-making may help balance democratic participation with the urgency of environmental action.

The strong positive correlation between political stability and environmental performance emphasizes the need for policies that promote political continuity and institutional strength. Policymakers should recognize that stable political environments create a fertile ground for implementing and enforcing long-term environmental policies. Thus, enhancing political stability through conflict prevention, promoting the rule of law, and building resilient political institutions can indirectly improve environmental performance by enabling governments to focus on sustainable development without disrupting political crises. Moreover, governments in politically stable environments are better positioned to attract investments in green technologies and sustainable infrastructure, which can further boost environmental performance.

The study's findings regarding government effectiveness and its paradoxical negative impact on environmental performance highlight the need for a balanced approach to governance. While governments should strive for effectiveness in delivering public services and ensuring economic growth, this effectiveness must be aligned with environmental objectives. Policymakers should integrate sustainability into the core of governance by ensuring that government efficiency does not come at the expense of environmental degradation. For example, policies that promote sustainable industrial practices, green infrastructure development, and environmental considerations in economic planning can help bridge the gap between effective governance and environmental performance.

The positive relationship between regulatory quality and environmental performance provides clear evidence for the importance of sound environmental regulations. Policymakers should focus on improving the quality of environmental regulations, ensuring they are clear, consistent, and adaptable to evolving environmental challenges. Policies incentivizing innovation, such as flexible regulatory frameworks that allow for technological advancement in environmental protection, can foster compliance while promoting sustainable economic growth. Additionally, voluntary environmental programs encouraging private sector participation in sustainability initiatives should be promoted as complementary to formal regulations. Governments should also ensure that regulatory agencies are well-resourced to monitor and enforce compliance effectively.

The negative association between the rule of law and environmental performance underscores the need for policies that go beyond the mere presence of legal frameworks. Policymakers should critically assess the content and focus of existing legal frameworks to ensure they align with environmental sustainability goals. Policymakers should strengthen environmental laws and improve their enforcement in countries with robust legal systems but poor environmental outcomes. Environmental impact assessments, more substantial penalties for violations, and the active involvement of civil society in monitoring compliance could help ensure that economic activities, even when legally sanctioned, do not undermine environmental sustainability.

Finally, the moderating role of economic prosperity in the relationship between governance and environmental performance suggests that policies aimed at improving environmental outcomes must account for the economic context. In wealthier nations, the availability of financial resources enables more effective implementation of environmental policies. However, in lower-income

countries, the lack of resources may limit the impact of governance reforms on environmental outcomes. Policymakers in these countries should prioritize economic growth strategies aligned with sustainable development, such as investing in renewable energy, green infrastructure, and environmental technologies. Additionally, international cooperation and financial support from wealthier nations or multilateral institutions could help lower-income countries bridge the resource gap and implement effective governance reforms that improve environmental performance.

9. Limitations and suggestions

While providing significant insights into the relationship between public governance and national environmental performance, this study is subject to several limitations that should be considered when interpreting the findings. First, the study's cross-sectional nature limits its ability to capture the dynamic, evolving relationship between governance structures and environmental outcomes over time. As the analysis is based on data collected from a single period (2006–2022), it may not fully reflect the temporal changes in governance and environmental performance or account for the long-term effects of governance reforms. Future research could benefit from employing longitudinal data to investigate causal relationships and examine how shifts in governance systems impact environmental outcomes over time.

Second, the study relies on aggregate governance indicators, such as voice and accountability or government effectiveness, which, while helpful in capturing broad trends, may mask essential variations within countries. Governance is often context-specific, and its effectiveness may differ between national and sub-national levels. The study also does not consider sector-specific governance factors, such as the performance of environmental ministries or agencies, which could offer more granular insights into environmental policy effectiveness. Further research could explore how governance quality varies across regions within countries or different governance sectors, such as environmental or economic governance, to provide a more nuanced understanding of the governance-environment nexus.

Third, while the study investigates the moderating role of economic prosperity, it does not fully account for the complex socio-cultural factors that may influence governance effectiveness and environmental outcomes. Factors such as political culture, social norms, and historical legacies can shape the interaction between governance and environmental performance, potentially altering the effectiveness of governance reforms. Future research could explore how cultural or regional differences mediate the relationship between governance structures and environmental outcomes, particularly in countries with unique political or social systems.

Additionally, the study's focus on governance and economic prosperity does not comprehensively address other critical factors that may influence environmental performance, such as technological innovation, international environmental agreements, or the role of global environmental governance institutions. While the research highlights the importance of governance, it does not fully account for the influence of external drivers such as foreign direct investment, international aid, or multinational environmental regulations. Future studies could investigate how these external factors interact with national governance structures to shape environmental performance, especially in developing countries with limited resources.

The environmental performance index (EPI) helps measure national environmental outcomes but has some limitations. Its aggregated score can hide essential differences in specific areas, and data gaps or inconsistent reporting, especially in developing countries, can create bias. The EPI also lacks indicators that consider social and economic aspects of sustainability. Additionally, it only captures a snapshot in time, making it hard to assess long-term trends, and it tends to favor wealthier countries with more resources for environmental protection. Changes in the EPI's methodology over time further complicate comparisons. To improve future research, it's essential to break down the EPI into its components, use better data sources, including social and economic factors, track environmental performance over time, and adjust for economic differences between countries. Careful consideration of these issues will strengthen analyses of the relationship between governance and environmental performance.

Data availability

Data is available upon request.

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Declaration of competing interest

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