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Original Research Article

Integrating Environmental and Social Sustainability into Large-Scale Infrastructure Decision-Making: Evidence from Selected Cases

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Abstract

Large-scale infrastructure projects contribute to economic development, connectivity, energy security, and social welfare. However, they can also generate substantial environmental and social impacts. This study examines how environmental and social sustainability are incorporated into large-scale infrastructure decision-making through a multiple-case study analysis of three major projects: the Jakarta–Bandung High-Speed Rail in Indonesia, the Belo Monte Dam in Brazil, and the Adani Carmichael Mine in Australia. The cases represent different infrastructure contexts and reveal recurring tensions between economic development objectives, environmental protection, community interests, and long-term sustainability. Through cross-case analysis, the study identifies common challenges including the prioritisation of economic and strategic objectives, limitations in stakeholder participation, ecological impacts, and inadequate consideration of long-term social and environmental consequences. The findings indicate that regulatory compliance and conventional project appraisal do not necessarily ensure sustainable or socially legitimate infrastructure outcomes. The study therefore highlights the need to embed environmental and social considerations throughout infrastructure planning, assessment, approval, and governance. It proposes strengthened stakeholder participation, sustainability and ethical assessments, adaptive decision-making, climate-impact accounting, and biodiversity and social safeguards as key governance measures. The study concludes that sustainable infrastructure requires decision-making approaches that move beyond project delivery and procedural compliance towards integrated environmental and social sustainability.

Keywords: Environmental ethics, Infrastructure development, Environmental impact assessment (EIA), Biodiversity, Procedural justice, Precautionary principle, Climate accountability.

1. INTRODUCTION

Infrastructure such as transport, energy, water, and large-scale projects is central to national development plans worldwide. Governments and developers often justify these investments as drivers of economic growth, regional development, and improved human welfare. At the same time, these projects frequently generate significant environmental and social harms. Impacts include habitat fragmentation, species loss, altered hydrology, higher greenhouse-gas emissions, and adverse effects on local and Indigenous communities. They also contribute to air pollution, noise, and vibration (Robinah *et al.,* 2022).

This creates a tension between the pursuit of economic prosperity and the ethical obligation to preserve environmental values. Legal compliance sets the minimum standard, but it often falls short of addressing broader ethical responsibilities in infrastructure development.

This paper examines the intersection of environmental ethics and law in major infrastructure projects. Law and ethics are not interchangeable. Legal frameworks establish baseline standards and procedures, such as environmental impact assessments, licensing, and judicial review, yet they often leave significant ethical questions unresolved. This gap is particularly evident in matters of long-term ecological integrity, intergenerational equity, and distributive justice (Poorhashemi, 2024).

Despite increasing recognition of these challenges, there is limited research on how ethical considerations can be systematically integrated into legal and governance frameworks for infrastructure. Existing

studies often focus on technical compliance or environmental assessment procedures without addressing deeper ethical tensions. Moreover, comparative insights across different political, legal, and socio-economic contexts remain sparse.

The objectives of this paper are threefold. First, it seeks to identify recurring ethical tensions in infrastructure development. Second, it examines how existing legal frameworks accommodate or fail to accommodate these ethical concerns. Third, it proposes governance tools and reforms to better integrate ethical considerations into decision-making, ensuring that infrastructure development is both socially legitimate and environmentally responsible.

The scope of the study is global. Case studies covering sectors such as transport, energy, and resource extraction from Asia, South America, and Australia are used for this study. By highlighting ethical gaps and proposing practical reforms, this paper aims to bridge the divide between legal minimums and broader ethical imperatives, contributing to more sustainable infrastructure governance.

Further, investment is generally driven by expectations of improved connectivity, productivity, employment, investment, and social welfare. However, the pursuit of these economic and developmental objectives can create tensions when short-term economic imperatives conflict with long-term environmental protection and social justice. Therefore, sustainable infrastructure governance requires decision-making frameworks that consider not only economic benefits and legal compliance but also the distribution of environmental and social costs across affected communities and future generations. This perspective reinforces the need to integrate ethical considerations into infrastructure governance so that economic development can be pursued without compromising ecological integrity and social equity.

2. LITERATURE REVIEW

2.1 Environmental ethical perspectives

Environmental ethics offers several ways to think about choices in infrastructure. Utilitarian approaches focus on overall welfare, weighing benefits against harms in cost–benefit terms. (Naeeni, 2023). However, utilitarianism has clear limits in environmental debates. It tries to measure things like happiness, health, or ecological value, but these are not easy to quantify (Emina, 2023). It also struggles with long-term and intergenerational impacts, since consequences are hard to predict. Critics argue that utilitarianism treats individuals as means to maximize overall happiness, rather than as beings with inherent rights and dignity (Emina, 2023).

On the other hand, Deontological perspectives emphasize rights and duties, highlighting risks to Indigenous peoples, local communities, and even non-human species with intrinsic value. Virtue ethics brings attention to stewardship, prudence, and responsibility in decision-making. Deep ecology, goes further by rejecting human-centered thinking and affirming the intrinsic worth of ecosystems, even when this conflicts with economic priorities (Davidson, 2023).

Emina (2023) notes that most environmental policies still treat nature mainly in instrumental terms, valuing it for what it provides to humans. As a result, many of these policies fail to truly protect ecological systems. A stronger foundation can be built if policies are grounded in deontological principles that recognize duties toward nature itself. Across ethical theories, the common thread is the notion of respect. Cultivating respect for nature among individuals and institutions can lead to more positive and lasting outcomes in environmental protection.

Environmental law has translated several ethical ideas into practical principles. The Rio Declaration's Principle 15 emphasizes the precautionary approach. It states that lack of full scientific certainty should not delay cost-effective measures to prevent serious or irreversible environmental harm (United Nations, 1992). Similarly, the Polluter Pays Principle also holds that those who are responsible for environmental damage should bear the associated costs (Barthakur, 2021). The Aarhus Convention (1998) goes beyond procedural safeguards by recognizing a substantive right to a healthy environment. While some of its language is ambiguous, the Convention emphasizes the importance of public access to information, meaningful participation, and access to justice in environmental decision-making (Barritt, 2024). These procedural rights aim to protect both current and future generations, ensuring that environmental governance reflects ethical responsibilities as well as legal requirements. By reinforcing the connection between participatory processes and environmental protection, the Aarhus Convention provides a practical mechanism for translating ethical principles into law.

The International Finance Corporation's (IFC) Performance Standards (2012) provide guidance for managing environmental and social risks in development projects. They emphasize proactive environmental stewardship, stakeholder engagement, and the protection of communities and ecosystems. By requiring companies to identify, mitigate, and monitor potential impacts, the standards translate ethical principles into actionable governance tools that complement legal requirements (International Finance Corporation, 2012).

2.2 Legal mechanisms and ethical gaps

Environmental law governing infrastructure projects relies on tools such as environmental impact assessments (EIA), environmental and social impact assessments (ESIA), licensing regimes, statutory

standards, and judicial review (Diaconu, 2024). These mechanisms provide a structured approach to anticipate and manage environmental effects, while also introducing elements of public participation and early-stage risk evaluation.

Legal frameworks often restrict the scope of ethical consideration. They narrow what is defined as the proposed action and set fixed temporal and spatial boundaries for analysis. They also emphasize compliance with mitigation or offsetting measures rather than deeper ethical responsibilities. Offsetting and mitigation often fulfil legal requirements but fail to account for nature's intrinsic values, reducing ecosystems to tradable components rather than respecting their inherent worth (Karlsson, 2022). This creates a gap between procedural compliance and broader ethical responsibility, particularly in addressing long-term or cumulative impacts such as climate change.

2.3 Infrastructure Development and Environmental Law: Tools, Limits, and Frictions

Environmental impact assessment (EIA)

Environmental impact assessments are one of the main tools used to anticipate and reduce harm before a project is approved. A strong assessment usually includes detailed baseline studies, meaningful consultation with stakeholders, consideration of alternatives, clear mitigation measures, and on-going monitoring. In theory, this process should help balance development with environmental protection. (Gulakov & Vanclay, 2024).

However, in practice, the quality of EIAs varies widely. Some countries apply strict rules and require active community engagement, while others rely on quick reviews or focus only on mitigation after damage has already occurred. This uneven application creates major gaps in how well projects actually safeguard people and ecosystems (Narain *et al.,* 2023).

2.4 Licensing, standards, and judicial review

Licensing regimes provide the legal authority that makes regulatory decisions binding and enforceable. They translate broad environmental standards into project-specific conditions. When disputes arise, courts can serve as a check. In some cases, judicial review has strengthened environmental protection by forcing agencies to respect participation rights or comply with substantive standards (Komoliddin, 2024). At the same time, courts often show deference to regulators, especially on technical questions like defining the project's scope or determining whether a specific impact is causally linked. This tension means that the effectiveness of judicial review can be unpredictable. In many cases, environmental laws are not strong enough to provide full protection for nature. Key areas of protection may be overlooked, and some frameworks struggle to keep pace with emerging scientific and technological developments (Insani & Karimullah, 2023).

2.5 The problem of boundaries: indirect and cumulative effects

A persistent limitation in environmental assessment lies in the delineation of project boundaries. When defined narrowly, assessments often fail to capture indirect and cumulative effects such as induced resource extraction, greenhouse gas emissions, and large-scale ecosystem disruption. This narrow framing can underestimate long-term impacts, particularly when multiple projects interact across time and space.

Empirical studies demonstrate that infrastructure construction exerts significant impacts on both landscape patterns and ecological processes. At the microscale, engineering activities frequently generate heavy metal contamination, altering soil structure and constraining species migration. At the landscape scale, such projects often result in persistent habitat fragmentation, reducing ecological connectivity and biodiversity resilience (Li *et al.,* 2022).

The ecological risks extend further. Rapid infrastructure expansion contributes to cumulative environmental stress, amplifying vulnerabilities in already fragile ecosystems (Li *et al.,* 2022). These indirect impacts are not always visible within the scope of individual assessments but become critical when considered collectively. Failure to account for such interactions risks shifting the environmental burden onto future generations, making boundary-setting in environmental assessment not only a technical challenge but also an ethical one.

2.6 Research Gap

Environmental impact assessments, licensing regimes, and legal standards are widely used in infrastructure projects. However, these frameworks often do not fully incorporate ethical considerations. Legal instruments tend to define narrow project boundaries and focus mainly on procedural compliance. As a result, indirect and cumulative effects, long-term ecological impacts, and intergenerational responsibilities are often overlooked.

Mitigation measures, such as biodiversity offsets, may meet regulatory requirements but can ignore the intrinsic value of ecosystems. Public participation mechanisms exist, but their effectiveness varies across countries. Ethical principles like justice, stewardship, and precaution are inconsistently applied.

This reveals a clear gap. Therefore, there is a need for research that explores how environmental ethics can be more effectively embedded into legal frameworks. Such work can help develop governance tools and policy reforms that balance economic growth with ecological sustainability and social equity.

This study uses a comparative case study approach to conduct this research and to address these gaps. The methodology in detail is outlined below.

3. METHODOLOGY

This study adopts a qualitative comparative case study approach. This is to examine how environmental ethics can inform decision-making within legal frameworks for infrastructure governance. Qualitative research is concerned with capturing subjective experiences and contextual meanings to address explanatory questions that are related to processes and causation rather than numerical analysis (Gamage, 2025). In line with this, the study employs a case study method, which enables an in-depth examination of specific instances to understand their unique characteristics, contextual dynamics, and underlying processes (Tomaszewski *et al.,* 2020). The study further does not aim to generalize statistically but to generate analytical insights applicable to infrastructure governance contexts.

The Jakarta–Bandung High-Speed Rail (Indonesia), the Belo Monte Dam (Brazil), and the Adani Carmichael Mine (Australia) which are three large-scale infrastructure projects selected as illustrative cases. These cases provide a diverse basis for comparative analysis across different geographic regions and governance contexts.

Case selection was guided by four criteria. First, the projects represent varied geographic and institutional settings across Asia, South America, and Australia, allowing cross-contextual comparison. Second, they span multiple infrastructure sectors, including transportation, energy, and resource extraction, enabling the identification of sector-specific governance challenges. Third, each case is associated with well-documented environmental and social impacts, including issues related to public participation, regulatory approvals, and legal disputes. Finally, the availability of reliable secondary data ensures that the analysis is grounded in credible and verifiable sources. Figure 1 is an illustration of case selection criteria used for this study.

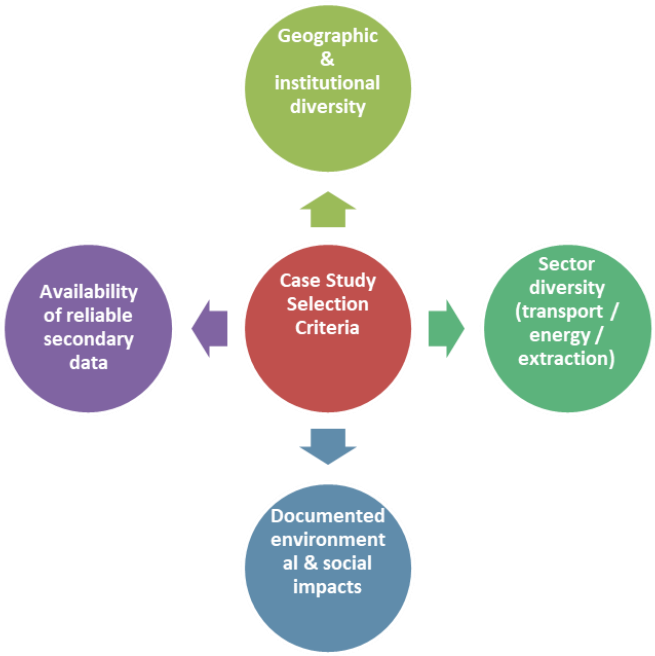

Fig. 1: Case Selection Criteria Framework

Data for this study were collected from secondary sources. These secondary sources include government reports, legal documents, environmental impact assessments, publications from international organizations, and peer-reviewed academic literature. The analysis is guided by an environmental ethics perspective, focusing on key principles such as fairness, the precautionary principle, and intergenerational equity.

A structured comparative framework is employed to analyze each case across three dimensions: (1) the extent of legal compliance in project approval and implementation, (2) the integration of ethical considerations within decision-making processes, and (3) the identification of governance gaps where economic priorities override environmental and social concerns. This analytical approach facilitates the identification of recurring patterns and systemic weaknesses across the selected cases.

By integrating ethical evaluation with legal analysis, this methodology supports the development of a decision-oriented governance framework aimed at enhancing infrastructure planning, approval, and monitoring processes.

4. DATA COLLECTION THROUGH CASE STUDIES: COMPARATIVE PERSPECTIVES

To operationalize the research design, three illustrative infrastructure case studies were selected from different regions and sectors. These cases, the Jakarta–Bandung High-Speed Rail (Indonesia), the Belo Monte Dam (Brazil), and the Adani Carmichael Mine (Australia) offer diverse perspectives on how environmental ethics interact with legal frameworks. They provide concrete examples of recurring tensions between economic growth, environmental sustainability, and social justice.

4.1 Case 1: Jakarta–Bandung High-Speed Rail (Indonesia)

The Jakarta–Bandung High-Speed Rail project, launched as Indonesia's first high-speed rail initiative, encountered significant challenges during its construction phase. Technical incidents, such as the explosion of a Pertamina fuel pipeline and the collapse of a support pillar, underscored safety risks and engineering shortcomings. In addition, cost overruns and delays placed substantial financial strain on the Indonesian government, ultimately requiring the allocation of state funds to sustain project continuity (Putri, 2024).

Beyond technical and financial issues, the project faced environmental and social disruptions, including flooding, traffic congestion, and land-related disputes, which contributed to public dissatisfaction. The project also revealed gaps in governance and regulatory practice, as principles of participation, transparency, efficiency, accountability, legal certainty and inclusiveness were not fully upheld in its development as a national strategic project (Constanta, 2024).

This case illustrates the tension between economic ambitions and sustainability considerations, highlighting how inadequate application of environmental ethics and legal safeguards can undermine both public trust and project legitimacy.

4.2 Case 2: Belo Monte Dam (Brazil)

The Belo Monte Dam project in Brazil faced decades of legal and political disputes before construction began in 2011 and operations commenced in 2019. While promoted as a driver of national economic growth, the project exposed deep tensions between development goals, social justice, and environmental stewardship (Björkman, 2024).

The dam significantly altered the Xingu River ecosystem, resulting in habitat destruction, biodiversity loss, and declining water quality. Poorly managed vegetation flooding increased organic pollution, raising carbon levels and reducing oxygen concentrations in the river. These ecological shifts adversely affected aquatic life and undermined the resiliency of one of South America's most important clearwater basins (Macias Gimenez, 2021).

For Indigenous and traditional communities, the consequences were severe. Many faced displacement, restricted access to river resources, and a loss of cultural ties to their ancestral lands. Social inequalities deepened as these groups bore the heaviest costs of development, while decision-making processes often excluded their voices. Despite official promises of benefits, lawsuits were filed against Norte Energia for failing to comply with safeguards and for exacerbating livelihood losses in the region (Kleeberg, 2021).

Overall, the Belo Monte case demonstrates how weak oversight, inadequate assessments, and entrenched power imbalances allowed economic and political interests to override ethical and environmental considerations, leaving marginalized groups and fragile ecosystems most vulnerable (Björkman, 2024).

4.3 Case 3 - Adani Carmichael Mine (Australia)

The Carmichael Mine and Rail Project (CCMRP), located in the Galilee Basin of Queensland, represents one of Australia's most controversial infrastructure developments. Approved in 2019 after nearly a decade of legal and political disputes, the project includes a coal mine, a 189-kilometer rail line, and new port facilities (Lodhi, 2024; Stutzer, 2021). From its inception, the project drew intense scrutiny due to its scale and potential to exacerbate global climate change.

The environmental impacts of the project are profound. The mine is expected to significantly increase Australia's already high per capita CO_2 emissions, undermining global decarbonization efforts (Stutzer, 2021). Construction activities, including extensive dredging to establish port access, pose direct threats to the Great Barrier Reef World Heritage Area. Furthermore, concerns have been raised about the long-term integrity of the Great Artesian Basin, one of Australia's most vital groundwater reserves (Lodhi & Thampapillai, 2024).

Biodiversity and land rights issues further complicate the project. The development threatens endangered species habitats and has been linked to conflicts over Native Title and the rights of traditional Indigenous landowners (Lodhi, 2024). The loss of ecosystems, coupled with the underestimation of greenhouse gas emissions in project assessments, highlights weaknesses in both legal review processes and environmental accountability frameworks.

Despite widespread opposition and strong scientific consensus regarding the irreversible damage likely to result, the project advanced. Political and economic pressures played a decisive role, with the coal industry's structural power shaping government decisions (Stutzer, 2021). This case illustrates the tension

between economic dependence on resource extraction and ethical obligations to protect ecosystems, Indigenous rights, and future generations.

Table 1 presents a summary of the three case study projects and their associated environmental and social effects. It highlights the recurring ethical tensions, legal gaps, and broader implications for sustainable infrastructure governance.

Table 1: Ethical–Legal Gaps in Infrastructure Projects Summary

Case Study	Country / Sector	Main Ethical Tensions	Legal Framework / Gaps	Outcomes & Lessons
Jakarta–Bandung High-Speed Rail	Indonesia / Transport	Safety risks, land disputes, flooding, weak participation, public dissatisfaction	Formal compliance with EIA and licensing, but limited transparency, weak governance	Economic ambition overshadowed ethics; inadequate safeguards undermined trust and legitimacy
Belo Monte Dam	Brazil / Energy (Hydropower)	Displacement of Indigenous communities, biodiversity loss, cultural disruption, inequitable burden-sharing	Multiple legal disputes; weak oversight; safeguards poorly enforced	Development prioritized over justice; communities marginalized; ecosystems fragmented
Adani Carmichael Mine	Australia / Resource Extraction (Coal)	Climate change impacts, biodiversity threats, Indigenous land rights conflicts	Approved despite strong opposition; weak accountability mechanisms	Economic and political power dominated; long-term climate and ecological risks ignored

5. RESULTS & DISCUSSION

The three cases highlight recurring tensions between environmental ethics and legal frameworks. Although they differ in geography, sector, and governance context, several common themes emerge.

5.1. Limits of Legal Frameworks

Each project formally complied with regulatory requirements such as impact assessments and licensing. Yet compliance did not prevent significant environmental and social harm. This demonstrates how law often provides only a procedural safeguard rather than substantive protection of ecological or ethical values.

5.2. Marginalization of Communities

In all three cases, Indigenous and local communities were disproportionately affected. From displacement in the Xingu River Basin to conflicts over Native Title rights in Australia, affected groups had limited influence in decision-making processes. Ethical duties of respect, equity, and participation were overshadowed by economic and political priorities.

5.3. Environmental Externalities and Scale of Harm

The projects revealed challenges in addressing indirect and cumulative impacts. Jakarta–Bandung showed governance risks and safety failures; Belo Monte demonstrated long-term ecosystem fragmentation and biodiversity loss; Adani highlighted global climate risks. Although legal frameworks frequently define project boundaries in restricted ways, this can result in broader ethical consequences receiving limited consideration. These recurring tensions illustrate the ethical dilemmas inherent in balancing growth, justice, and ecological responsibility

5.4. Power Dynamics and Economic Pressures

Across all three contexts, powerful corporate and political interests prioritized economic growth narratives. These actors shaped legal interpretations and weakened enforcement, reinforcing structural inequalities. Ethical commitments to precaution, intergenerational equity, and ecological integrity were often overlooked. These findings show that while legal frameworks address compliance, they fail to adequately accommodate broader ethical concerns such as equity, precaution, and ecological integrity

5.5. Need for Integrated Governance

Taken together, the cases show that law, while necessary, is insufficient to safeguard environmental ethics. Stronger governance mechanisms are required to embed precaution, community participation, and ecological limits into infrastructure planning. This requires moving beyond procedural compliance toward frameworks that actively integrate ethics into decision-making.

Several tools and reforms can help close these gaps. Mandatory ethical audits would ensure that projects are assessed not only for regulatory compliance but also for their alignment with principles such as intergenerational equity and ecological integrity. Free, Prior, and Informed Consent (FPIC) can strengthen participatory rights by guaranteeing that Indigenous and local communities have meaningful influence over projects affecting their lands and livelihoods (Hofbauer, 2022). Climate impact accounting and adaptive licensing regimes would enable regulators to capture cumulative

and long-term risks, adjusting approvals as new evidence emerges. Finally, binding biodiversity net-gain or offset rules, anchored in international frameworks such as the Rio Declaration, Aarhus Convention, and IFC Performance Standards, would provide measurable safeguards against ecological degradation.

Comparative lessons therefore suggest that integrated governance is not only about stronger regulation but also about institutionalizing ethical reflection within infrastructure planning. Embedding these mechanisms can help balance growth, equity, and sustainability, while enhancing both legitimacy and resilience in large-scale development projects.

Figure 2 illustrates how recurring ethical tensions interact with the limits of existing legal frameworks, creating ethical–legal gaps in infrastructure governance. It also highlights proposed governance tools and reforms that can help integrate ethics more systematically into infrastructure planning and decision-making.

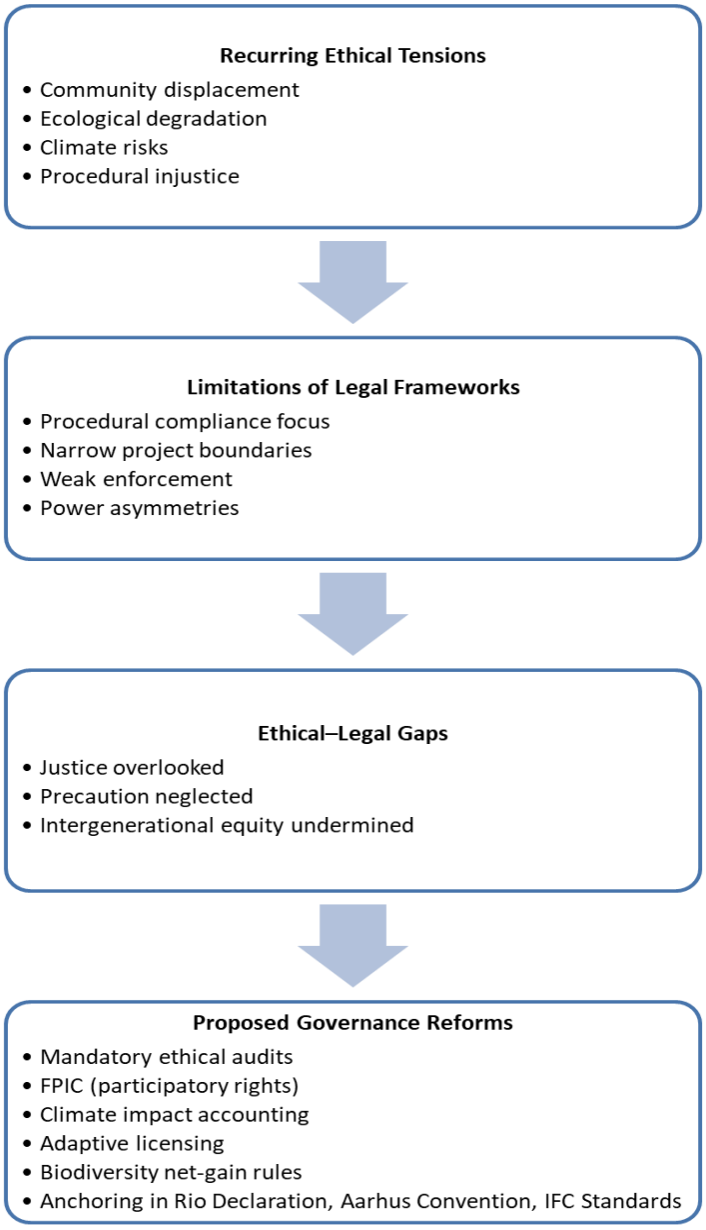

Fig. 2: Ethical–Legal Gaps and Governance Reforms in Infrastructure Development

6. CONCLUSION

This paper examined the intersection of environmental ethics and legal frameworks in major infrastructure development. Drawing on three illustrative case studies that are the Jakarta–Bandung High-Speed Rail, Belo Monte Dam, and Adani Carmichael Mine, it identified recurring ethical tensions. Those tensions include trade-offs between economic growth, ecological integrity, social justice, and intergenerational equity. These tensions highlight how large-scale infrastructure projects often lead to community displacement,

ecosystem degradation, and uneven distributions of risks and benefits.

The analysis further demonstrated that while legal compliance remains essential, existing regulatory frameworks are often insufficient in addressing deeper ethical concerns. Current laws tend to prioritize procedural compliance and narrowly defined project boundaries. This leaves cumulative environmental impacts, structural power imbalances, and long-term ecological risks inadequately regulated. In addition, weak enforcement mechanisms and strong economic pressures also contribute to widening the gap between legal requirements and ethical responsibilities, with Indigenous and local communities disproportionately affected.

To address these limitations, the study proposed governance reforms aimed at systematically integrating ethical considerations into infrastructure decision-making. These include the use of mandatory ethical audits, climate impact accounting, adaptive licensing mechanisms, and binding biodiversity net-gain requirements. Strengthening participatory governance through Free, Prior, and Informed Consent (FPIC) is also essential to ensure both procedural fairness and substantive justice. Embedding these mechanisms within established international standards can enhance both regulatory legitimacy and sustainability outcomes. The Rio Declaration, the Aarhus Convention, and IFC Performance Standards are considered as already established international standards.

In conclusion, sustainable infrastructure development requires more than legal compliance alone. It necessitates a governance approach in which environmental ethics and legal frameworks are mutually reinforcing. Such an approach can support more balanced infrastructure decision-making by recognising economic and development objectives alongside environmental protection, social equity, and long-term societal value. Infrastructure development can better balance economic objectives with environmental protection, social equity, and intergenerational responsibility by embedding ethical principles into formal decision-making processes.

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