
Original Research Article

The current state and future directions of environmental impact assessment

Yingxianxian Liu

Tohoku University, Sendai, 9808577, Japan

Abstract: Environmental Impact Assessment (EIA) is a systematic approach for identifying and evaluating potential environmental impacts of projects, aimed at mitigating environmental risks and achieving sustainable development. This paper reviews the current state of EIA research, discussing its theoretical framework, usual methods, as well as existing challenges. Traditional EIA approaches, such as environmental impact matrix, life cycle assessment, and spatial information technologies like GIS, still have some limitations such as data dependence and uncertainty in predictions. Emerging tools like machine learning are progressively improving EIA's precision and range. Key challenges consist of not enough public participation, inconsistent legal frameworks, and an absence of reliable data in certain areas. This paper also provides some suggestions for future research directions of EIA. Future research directions include improving the theoretical framework to integrate socio-economic impacts, adopting AI and IoT for real-time tracking, enhancing the effectiveness of public participation, fostering interdisciplinary cooperations, and addressing the challenges posed by globalization and climate change. By improving these areas, EIA will play a more important role in balancing economic development and environmental protection.

Keywords: Environmental Impact Assessment; Traditional EIA approaches; Key challenges; Future research directions of EIA

1. Introduction

As all of us know, we are presently encountering significant environmental issues, among the essential factors for which is the fast industrial development since the 21st century. The wastewater and contaminated materials discharged by different manufacturing enterprises have substantially influenced the environment we rely on for survival. To protect the environment, some countries have begun to conduct Environmental Impact Assessment (EIA) ^[1] on enterprise' manufacturing tasks to examine the prospective environmental impacts of their procedures. Via EIA, both enterprises and governments can identify potential environmental dangers ahead of time, allowing them to formulate preventive measures and schemes as necessary. This not only lowers the adverse influence of production tasks on the environment but also promotes the collaborated development of economy and environment. Consequently, EIA is an important tool for achieving sustainable development between humankind and nature. This paper will first review the current study status of EIA, after that discuss the main challenges it is currently facing, and finally provide recommendations for its future development directions.

2. Existing state of environmental impact analysis research study

2.1. Theoretical framework of environmental impact assessment

The academic framework of EIA normally includes six main phases: baseline environmental survey, environmental effect forecast, environmental impact analysis, public participation, decision assistance, and post-assessment. First, the baseline environmental survey is used to identify present environmental conditions, supplying a reference for succeeding predictions and evaluation. After that, the assessment team anticipates

the potential environmental effects of the project through scientific data analysis models. Based on this, they execute a detailed evaluation of the project's environmental risks utilizing both quantitative and qualitative approaches. Public participation holds an important role in the EIA procedure, efficiently promoting stakeholders' understanding and support for the task. Finally, post-assessment guarantees that the project remains to satisfy environmental requirements during application. Although the fundamental EIA framework is relatively constant around the world, some execution methods vary throughout countries and areas, specifically regarding to regulations and policies.

2.2. Usual eia methods and tools

Currently, commonly used approaches and tools in EIA study consist of quantitative analysis, spatial data technology, and software applications. Traditional approaches^[2], such as environmental impact matrix, ecological footprint analysis, and Life Cycle Assessment (LCA), help assessment teams evaluate different environmental effects. With technical developments, spatial data technology like Geographic Information System (GIS)^[3] and remote sensing have actually been widely taken on in EIA to define project impact areas and manage spatial data. Additionally, water quality models, air quality models, noise prediction models, and relevant software supply important support for EIA. Although these devices work in anticipating environmental influences, they still have limitations, such as a high dependence on input data, which may result in mistakes. Lately, large information and machine learning have gradually been presented into the EIA area, improving the accuracy of forecasts and take the chance of recognition with comprehensive information evaluation.

2.3. Key issues and challenges in present EIA research

Although it has been applied globally, EIA study still deals with lots of problems and challenges^[4]. First, at the lawful and institutional level, some nations or regions do not have extensive EIA regulations, resulting in suboptimal implementation. Furthermore, public participation usually becomes a rule, stopping working to truly reflect stakeholders' voices and reducing its performance in the EIA procedure. Moreover, as the limitations in forecast models and the complexity of input information, EIA predictions and evaluations commonly encounter uncertainties, which might bring about overestimation or underestimation of environmental influences. In some countries, particularly financially underdeveloped areas, information shortages and errors restrict the dependability of EIA. These problems show that the concept and techniques of EIA require more renovation to satisfy new environmental protection requirements.

3. Future development directions of environmental impact assessment research

3.1. Improving the EIA framework in theory and practice

To address increasingly complex environmental problems, there is a demand to further enhance the theoretical and practical framework of EIA. Currently, the EIA structure frequently concentrates on natural environmental impacts while ignoring socio-economic variables, which would certainly supply a much more comprehensive assessment. Furthermore, in the context of international challenges such as environment change, EIA needs to perform dynamic, long-term environmental impact predictions and changes to better accommodate future uncertainties.

3.2. Incorporating intelligent technologies

With the improvement of Artificial Intelligence (AI) and machine learning^[5], EIA might better enhance

forecast and evaluation precision by integrating modern intelligent technologies. As an example, deep learning versions for multi-variable forecast can resolve some restrictions of traditional EIA designs. The application of huge data technology can also sustain EIA by accumulating and analyzing environmental information from numerous measurements, thus giving a basis for extra accurate forecasts of influence areas. In addition, real-time monitoring devices based on the Internet of Things (IoT) can gather environmental information in real-time, making that assessment data is prompt and reliable.

3.3. Enhancing public participation effectiveness

Future EIA public participation processes can be better enhanced via modern technology. As an example, on-line participation platforms permit stakeholders to access project environmental information and provide comments any time; Virtual Reality (VR)^[6] technology can imitate a task's potential environmental influences, assisting the public recognize assessment results more intuitively. Furthermore, making sure openness in the public participation process and stressing public responses can increase the reliability and social approval of EIA.

3.4. Strengthening interdisciplinary research

EIA is an interdisciplinary field, and future research can further enrich EIA content through deeper interdisciplinary collaboration. For example, combining theories from sociology, economics, and environmental science can help formulate more scientifically sound assessment schemes. In terms of policy and management, future research could explore how policy tools (such as taxes, subsidies, etc.) support companies and government agencies in better implementing EIA, effectively promoting the balance between environmental protection and economic development.

3.5. Addressing new challenges of globalization and climate change

With the accelerating pace of globalization and the intensification of climate change, EIA faces new challenges. Future EIA research should focus on the environmental impact assessment of transnational projects, particularly infrastructure projects involving multiple countries. Additionally, the dynamic environmental changes brought about by global climate change require EIA to have dynamic adaptability, allowing adjustments to project environmental impacts based on changing climate conditions to address future environmental uncertainties more effectively.

4. Conclusion

This paper reviews the current state of Environmental Impact Assessment, discussing its main achievements and limitations in theory, methods, and practice. Although EIA has become an essential environmental protection tool, it still faces numerous challenges in legal regulations, public participation, and technological applications. Looking ahead, EIA needs to make further progress in intelligent technology, interdisciplinary integration, public participation, and policy support to adapt to increasingly complex environmental issues. By continuously improving the theory and practical framework of EIA, we can better support the achievement of sustainable development goals and play a more significant role in global environmental protection.

Author the author

Yingxianxian Liu (1997-), female, Han ethnicity, from Suzhou, Jiangsu Province, China, master's student, research direction: Environmental Science

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