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Research Paper

Review of Environmental Impact Assessment Practices in Electronic Component Manufacturing Enterprises in Industrial Parks of Thai Nguyen Province, Vietnam

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Abstract
The rapid growth of the electronics manufacturing industry in Vietnam has contributed significantly to economic development but has also raised critical environmental concerns. Environmental Impact Assessment (EIA) serves as a crucial tool for identifying and mitigating environmental risks linked to industrial progress. This review focuses on the implementation of EIA practices within electronic component manufacturing enterprises operating in industrial parks in Thai Nguyen province. The research compiles and reviews existing environmental regulations, evaluates representative EIA reports, and examines common environmental management strategies adopted by these enterprises. Findings reveal that while most companies adhere to legal requirements by preparing EIA reports and recommending environmental protection measures, notable gaps persist. These include inadequate baseline environmental data, overly simplified methods for impact prediction, and difficulties in maintaining effective long-term monitoring programs. The study underscores the necessity of improving data accuracy, refining assessment methodologies, and fostering better collaboration between enterprises and regulatory bodies to enhance environmental management and support sustainable industrial growth.

Keywords: *Environmental impact assessment, electronics manufacturing, industrial parks, environmental management, Thai Nguyen province.*

I.Introduction

Over the past decade, the electronics manufacturing sector has become integral to Vietnam's economic development trajectory. Fueled by rapid growth in foreign direct investment and the integration into global supply chains, several northern provinces have been transformed into prominent hubs for producing electronic components and consumer electronics. Among these, Thai Nguyen has risen as a central player due to its strategic location, advanced industrial infrastructure, and investor-friendly policies. The expansion of the electronics industry has delivered significant economic advantages to the region, such as job creation, technology transfer, and a surge in export revenues. Industrial parks in Thai Nguyen province now host numerous enterprises specializing in electronic components, greatly contributing to the national economy. Nonetheless, this growth has brought environmental challenges. The manufacturing of electronic components involves highly intricate processes that utilize an array of chemicals, metals, solvents, and energy-intensive technologies. These processes generate pollutants such as heavy-metal-laden wastewater, chemical air emissions, and hazardous solid waste. To manage these risks, Environmental Impact Assessment (EIA) serves as a critical tool in identifying and mitigating potential environmental consequences during the planning phase of industrial projects. EIAs aim to evaluate the effects of proposed developments on crucial areas such as air quality, water resources, soil health, ecosystems, and local communities. Based on identified risks, developers implement mitigation measures to minimize environmental harm and adhere to regulatory standards. Vietnam's legal framework surrounding Environmental Impact Assessment has progressed significantly. The Law on Environmental Protection requires that projects with potentially significant environmental impacts undergo a thorough EIA process. These assessments must receive approval from competent authorities before any project is initiated, making the EIA an essential mechanism for environmental governance and pursuing sustainable industrial growth. However, even with a well-established regulatory framework, implementing EIA in developing countries faces persistent challenges. Limited technical expertise, inadequate environmental data, inconsistent assessment methodologies, and weak monitoring systems after project approval are common obstacles. As Vietnam’s electronics manufacturing sector continues to expand rapidly, it remains vital to evaluate whether current EIA practices sufficiently address environmental risks

associated with industrial activities. Thai Nguyen province offers an important case study for assessing the effectiveness of EIA practices within Vietnam's electronics manufacturing sector. The province has undergone significant industrialization in recent years, primarily in electronic component production. Industrial zones such as Yen Binh, Song Cong, and Diem Thuy have attracted numerous domestic and international investors specializing in electronic devices, circuit boards, and related components. The growing density of electronics manufacturing enterprises within these zones raises critical questions about long-term environmental sustainability and public health. Robust Environmental Impact Assessment processes are indispensable to ensuring developmental progress does not come at the cost of serious environmental degradation. Reviewing current EIA practices in this sector can yield crucial insights for strengthening environmental governance in industrially intensive regions. This study seeks to examine current Environmental Impact Assessment practices among electronic component manufacturers operating in Thai Nguyen's industrial parks. The research specifically focuses on analyzing the structure and content of EIA reports, evaluating impact assessment methodologies, highlighting limitations within the process, and proposing actionable recommendations for enhancing the quality and effectiveness of EIA implementation. The findings from this study aim to support policy improvements in Vietnam's industrial sector by addressing gaps in current EIA practices. By providing evidence-based recommendations, the study will serve as a valuable resource for policymakers, environmental consultants, and industrial stakeholders striving for sustainable development within the electronics manufacturing industry.

II. Research Methods

This study adopts a qualitative review approach to analyze Environmental Impact Assessment practices in electronic component manufacturing enterprises located in industrial parks in Thai Nguyen province. Several complementary research methods were employed to collect and analyze relevant information.

2.1 Literature review

The literature review method was used to synthesize theoretical and regulatory foundations related to Environmental Impact Assessment and environmental management in industrial development. Relevant academic publications, government documents, environmental regulations, and previous studies were analyzed to understand the general principles of EIA implementation. The review also included international research on environmental assessment practices in the electronics manufacturing industry to provide comparative perspectives.

2.2 Document analysis

The study analyzed a number of Environmental Impact Assessment reports prepared for electronic component manufacturing projects in industrial parks in Thai Nguyen province. These documents were examined to identify common structures, assessment methods, environmental indicators, and mitigation strategies used in practice.
Particular attention was paid to the following aspects of the reports:

- Environmental baseline data
- Identification of pollution sources
- Impact prediction methodologies
- Proposed environmental mitigation measures
- Environmental monitoring programs

2.3 Comparative analysis

Comparative analysis was conducted to evaluate similarities and differences among various EIA reports. This approach helped identify common trends and recurring issues in environmental assessment practices within the electronics manufacturing sector.

2.4 Expert experience analysis

The study also incorporates practical insights from environmental management and consulting practices related to industrial projects. These experiences provide additional perspectives on the challenges encountered during the preparation and review of Environmental Impact Assessment reports.

III. Environmental Characteristics of Electronic Component Manufacturing

Electronic component manufacturing encompasses diverse production processes, such as circuit board fabrication, semiconductor processing, electronic module assembly, and surface finishing techniques. These operations rely heavily on various chemical substances, including acids, solvents, cleaning agents, and metal plating solutions. Consequently, the electronics manufacturing sector exhibits distinct environmental challenges that necessitate careful oversight and mitigation. Wastewater generation The manufacturing processes often

produce wastewater containing chemical contaminants, heavy metals, and suspended solids. Without adequate treatment, these pollutants can severely impact surface and groundwater quality. Air emissions Certain stages in production involve activities like heating, chemical reactions, and solvent evaporation, which may result in the release of volatile organic compounds (VOCs) and other airborne pollutants. Hazardous waste This industry also generates significant amounts of hazardous waste, such as chemical sludge, spent solvents, contaminated packaging materials, and discarded electronic components. Energy consumption Due to the operation of precision equipment and maintenance of controlled production environments, electronic manufacturing facilities are typically high consumers of electricity. These environmental considerations underscore the critical need for comprehensive Environmental Impact Assessments during the design, planning, and construction phases of electronics manufacturing facilities.

IV. Current Practices of Environmental Impact Assessment in Industrial Parks of Thai Nguyen

The review of Environmental Impact Assessment reports reveals several common features in the environmental management practices of electronic component manufacturing enterprises in the industrial parks of Thai Nguyen province.

4.1 Structure and content of EIA reports

Most Environmental Impact Assessment reports prepared for electronics manufacturing projects follow the structure required by Vietnamese environmental regulations. The reports typically include the following sections:

- Introduction and project description
- Environmental baseline conditions
- Identification of potential environmental impacts
- Environmental mitigation measures
- Environmental monitoring programs

This standardized structure ensures that essential environmental issues are addressed in the assessment process.

4.2 Environmental baseline data

Environmental baseline data play a crucial role in evaluating potential environmental impacts. Most EIA reports include baseline information related to air quality, water quality, soil conditions, and local ecological characteristics.

However, the availability and quality of baseline data vary considerably among different reports. In some cases, environmental surveys are limited to short-term monitoring activities, which may not fully reflect seasonal variations in environmental conditions.

4.3 Impact prediction methods

Environmental impact prediction is an important step in the EIA process. The reviewed reports typically apply basic analytical methods to estimate potential environmental impacts.

For example, wastewater discharge volumes are calculated based on projected production capacity, while air emissions are estimated using emission factors derived from industrial guidelines. Although these approaches provide a general understanding of environmental risks, they may not always capture complex interactions between industrial activities and local ecosystems.

4.4 Environmental mitigation measures

Most EIA reports propose environmental mitigation measures such as:

- installation of wastewater treatment systems
- air emission control technologies
- proper storage and management of hazardous waste
- implementation of environmental monitoring programs

These measures are designed to ensure that industrial activities comply with environmental standards and regulations.

4.5 Environmental monitoring programs

Environmental monitoring programs are usually included in EIA reports to track environmental performance during project operation. Monitoring activities typically involve periodic sampling of wastewater, air emissions, and workplace environmental conditions.

However, the long-term effectiveness of these monitoring programs depends on consistent implementation and enforcement by both enterprises and regulatory authorities.

V. Results and discussion

The analysis of Environmental Impact Assessment (EIA) practices within electronic component manufacturing enterprises located in industrial parks in Thai Nguyen province provides valuable insights into the current state of environmental management in the industry. Findings indicate that most enterprises generally conform to Vietnam's environmental regulations. EIA reports are typically structured and prepared in alignment with the Law on Environmental Protection and related regulatory documents. This suggests that Vietnam's legal framework for environmental assessment is well-integrated into industrial practices and adopted by both businesses and consulting firms. Such compliance reflects a growing sense of environmental responsibility among stakeholders in the electronics manufacturing sector. Despite this adherence, several shortcomings regarding the quality and effectiveness of EIA reports have been identified. One major issue involves baseline environmental data, which is essential for accurately evaluating potential impacts and designing targeted mitigation strategies. Many surveys used to establish baseline data are conducted over short periods and rely on limited sampling points, resulting in data that may inadequately represent long-term environmental conditions. Another significant challenge lies in the methodologies used to predict environmental impacts, which often lack sophistication. Standard estimation techniques are commonly applied to calculate levels of pollutant emissions and wastewater discharge. While useful for basic evaluations, these methods frequently fail to account for complex dynamics such as cumulative impacts, regional pollution trends, and climate-related variables. Incorporating advanced modeling techniques and comprehensive analytical tools could substantially enhance the precision of impact predictions. Furthermore, the mitigation measures proposed in many EIA reports often follow generic templates rather than being specifically tailored to individual project requirements. For example, descriptions of technologies like wastewater treatment systems or air pollution controls often lack detailed technical assessments regarding their effectiveness under unique operational conditions. This generic approach may reduce the practical utility of these solutions. Issues also persist in post-approval phases, particularly regarding the implementation and monitoring of environmental measures. While EIA reports commonly include monitoring plans, their effective enforcement depends heavily on enterprise management and regulatory oversight. In practice, resource constraints and limited technical expertise within environmental management agencies frequently hinder robust monitoring efforts. Strengthening collaboration among enterprises, consulting firms, and regulators could help address these challenges. The rapid growth of electronics manufacturing in Thai Nguyen province introduces further complexities that exceed project-specific assessments. Industrial parks housing multiple manufacturing operations may produce cumulative environmental impacts that isolated EIA reports fail to account for. A shift toward integrated assessment strategies that evaluate collective impacts within a region should be prioritized. Positive developments within the sector provide a promising outlook. Many multinational corporations operating in Vietnam have adopted international environmental standards, such as ISO 14001, which encourage continuous improvement, systematic performance monitoring, and greater transparency in reporting. Integration into global supply chains further incentivizes enterprises to elevate their environmental management practices. External stakeholders often impose strict requirements, prompting businesses to invest in advanced technologies and adopt cleaner production methods. In summary, this study highlights the importance of enhancing the technical rigor and practical effectiveness of Environmental Impact Assessments in the electronics manufacturing sector. Addressing existing gaps while strengthening governance frameworks could drive significant improvements in sustainable industry practices.

VI. Conclusion

This study assessed the current state of Environmental Impact Assessment implementation in electronic component manufacturing projects located in industrial parks in Thai Nguyen province. The analysis demonstrated that the EIA framework is widely adopted and generally aligns with Vietnam's environmental regulatory standards. Typical EIA reports address key areas such as baseline environmental assessments, identification of pollution sources, and suggested mitigation strategies. However, shortcomings were observed in areas such as the quality of baseline data, the robustness of impact prediction methodologies, and the efficacy of post-approval environmental monitoring systems. To enhance EIA effectiveness, it is imperative to establish more comprehensive systems for environmental data collection, adopt advanced assessment techniques, and strengthen collaboration among enterprises, environmental experts, and regulatory agencies. Elevating the standards of Environmental Impact Assessment processes will not only improve environmental stewardship but also facilitate the sustainable development of northern Vietnam’s rapidly expanding electronics manufacturing sector.

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