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Characterization of National Eco-Industrial Park Demonstration Projects in Indonesia

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The Eco-Industrial Park (EIP) concept has emerged as a critical strategy for sustainable industrialization, yet its practical transition in developing nations requires careful scholarly evaluation. This study characterizes the early-stage performance of Indonesia's national EIP demonstration projects, focusing on the interplay between governance structure, industrial symbiosis, and financial viability. Using mixed-methods analysis, this research identifies that while initial results show promising improvements in resource efficiency, the overall transition is impeded by major regulatory fragmentation and a policy-practice gap. The result of this study contributes to the scholarly community by identifying specific challenges, such as regional infrastructural gaps and institutional thickness, that are often overlooked in centralized EIP models. The findings highlight that scaling sustainable production systems requires a reconsideration

of EIP governance that balances international best practices with local administrative realities. This evidence-based characterization offers academically and practically important insights for scaling pilot initiatives into nationwide sustainable production systems and provides recommendations for the Indonesian EIP roadmap.

Keywords: eco-industrial park, transition, industrial symbiosis, characterization, roadmap.

Introduction

The purpose of industrial ecology (IE) is to protect the environment while improving business success. This concept, directly linked to sustainable development, appeared in the 1970s (Gussow and Meyers, 1970; Hoffman, 1971; Watanabe, 1972). The term "industrial ecology" was then promoted by Frosch and Gallopoulos (1989). Indeed, in natural ecosystems, energy and material use are optimized, while waste and pollution are minimized.

Companies in the EIP can be seen as distinct hierarchical levels in terms of energy and material circularity within natural ecosystems. An EIP refers to an industrial complex that operates through industrial symbioses or by-product exchanges within a continuum of different levels of complexity (Côté and Cohen-Rosenthal, 1998; H. Kim, 2007). Meanwhile, according to the United Nations Industrial Development Organization (UNIDO), EIP is defined as "a dedicated area for industrial use at a suitable site that promotes sustainability by integrating social, economic, and environmental considerations into its siting, planning, management, and operations (UNIDO, 2017). To achieve these goals, EIP incorporates principles of the circular economy and cleaner production, encouraging sustainable development through networks that enable businesses to collaborate to enhance their environmental, economic, and social outcomes. This collaboration is driven by "industrial symbiosis" (IS), as demonstrated by the Kalundborg model, in which companies exchange materials, energy, and by-products, turning waste from one into a resource for another to boost efficiency and minimize environmental impact (Schlüter et al., 2023).

It is essential to develop a detailed understanding of how EIP models must be tailored to align with the country's distinct economic, social, and cultural characteristics, thereby contextualizing these findings within a specific national setting. Kalundborg, Denmark, has long been regarded as a benchmark for successful IS, yielding notable economic, environmental, and social benefits through resource sharing, waste reduction, renewable energy utilization, and community engagement (Jacobsen, 2006). However, efforts to replicate and scale this model in other countries, such as the United States, the Netherlands (Heeres et al., 2004), the United Kingdom (Mirata, 2004), Australia (Roberts, 2004), Brazil (Veiga and Magrini, 2009), and Egypt (Sakr et al., 2011) have largely fallen short of achieving sustained implementation and mainstream integration.

Research on EIP in Indonesia plays a distinct academic role as an empirical testing ground for implementing international best practices, such as the Global Eco-Industrial Park Programme (GEIPP) framework, adapted to the infrastructural realities of a developing country. This has led to the development of tailored methodologies like the Waterfront Industrial Estate Sustainability Index (Fitrianto et al., 2020). Moreover, this research area extends beyond policy evaluation to offer important theoretical insights into the financial aspects of brownfield redevelopment and Public-Private Partnerships (PPPs), thereby addressing a gap in comparative studies that have traditionally focused on East Asian studies. By examining the Indonesian case, this study questions the 'one-size-fits-all' governance assumptions often found in the IE literature, suggesting that EG in countries with regional autonomy requires a more decentralized, adaptive institutional framework than the centralized models observed in China and South Korea.

Drawing lessons from the implementation of EIP programs in various countries, it is evident that not all initiatives have achieved outcomes comparable to Kalundborg's success. This underscores the importance of critically evaluating EIP planning in Indonesia, particularly given the substantial number of industrial estates projected to reach 171 by 2025 (Schreier et al., 2024). Although the EIP concept was formally introduced in Indonesia in 2021, recent evaluations show that, despite significant progress, no industrial estate in the country has fully met the International EIP Framework requirements. This highlights a significant opportunity for improvement (UNIDO et al., 2024). To

enhance the effectiveness and scalability of EIP initiatives, it is essential to align the conceptual framework with the country's unique economic structures and socio-cultural dynamics.

The key points of this study include: 1) "What are the key characteristics of successfully implemented EIP models?", 2) "How do the national regulatory and institutional aspects support the implementation of the EIP program?", and 3) "Recommendation for national Indonesian EIP roadmap". To support the implementation of the Indonesian EIP program, a systematic review analysis is required. In previous research, the comparison of EIP in three East Asian countries (China, Korea, and Japan) was characterized (Putra et al., 2024) and Indonesian EIP blueprint was developed (Tamtomo et al., 2025).

Therefore, this paper examines how Indonesia's national EIP program has evolved within its institutional and policy framework. It is structured into four interconnected parts: a discussion of the planning phase of EIP development in Indonesia, followed by an analysis of the national EIP program's implementation strategies and enabling mechanisms. The third part presents a comparative and financial analysis, drawing insights from international standards and best practices relevant to EIP implementation. The final section outlines the roadmap and key recommendations to guide Indonesia's transition toward sustainable, inclusive, and competitive industrial ecosystems.

Methods

Theoretical and framework

To navigate the analytical complexity of Indonesia's EIP transition, this study is anchored in two theoretical pillars: IE and Environmental Governance (EG). The IE framework has evolved from analyzing isolated material flows to emphasizing IS, the physical exchange of resources, energy, and by-products among collocated firms (Chertow, 2000). Unlike the global benchmark of Kalundborg, which represents a spontaneous, 'self-organizing' symbiosis, Indonesia exemplifies a 'planned' EIP model intentionally engineered through policy interventions (Chertow et al., 2019; Park et al., 2016). This theoretical distinction is vital for evaluating the applicability of the GEIPP framework within emerging economies.

Complementing this technical perspective, EG theory is used to examine the underlying institutional dynamics shaping environmental outcomes (Lemos and Agrawal, 2006). In Indonesia's decentralized and archipelagic context, the EIP transition is not merely a technological hurdle, but a complex navigation of 'institutional fragmentation.' Overlapping regulatory mandates between the Ministry of Industry (MoI), the Ministry of Environment (MoE), and regional authorities frequently create bureaucratic barriers to systemic circularity. By synthesizing these dual lenses, this study transcends standard technical reporting to critically analyze how standardized global frameworks (UNIDO/GEIPP) are continuously negotiated against localized political, financial, and administrative constraints.

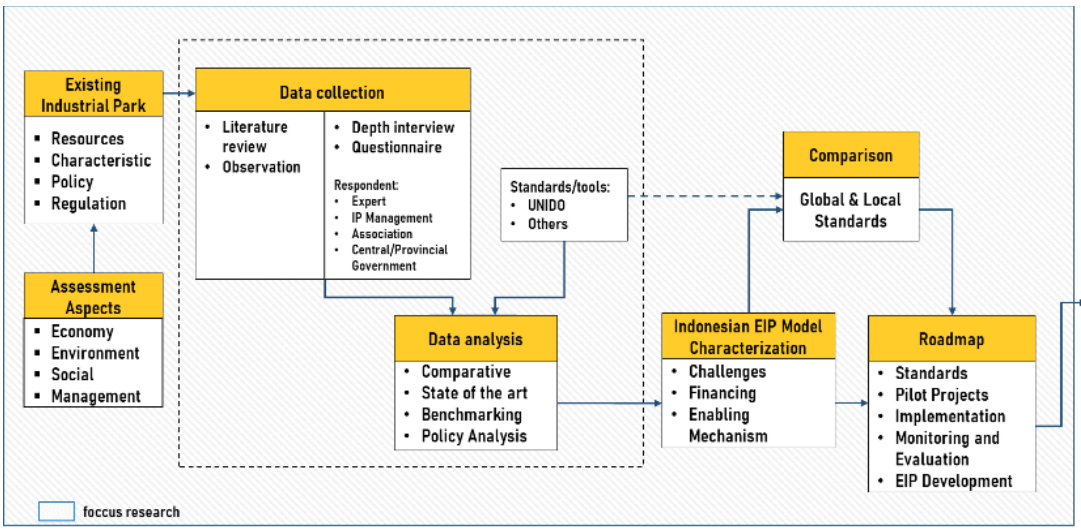
Grounding the methodology in EG theory, this study moves beyond technical characterization to analyze how standardized global frameworks are negotiated within localized political and financial constraints (see *Fig. 1*). An analytical framework was developed to outline key domains, indicators, and evidence criteria to guide future data collection and analysis. The study covers four aspects: economic, environmental, social, and management, which are directly connected to the resources, features, policies, and regulations of Indonesia.

To establish a solid comparative baseline, this study began with a focused review of literature and policy documents. Sources on IS and EIP governance were selected based on specific thematic criteria, specifically relied on the UNIDO EIP Implementation Handbook (UNIDO, 2017) and Government of Indonesia (GoI) regulatory frameworks to develop standardized assessment criteria. After a thorough credibility check, the collected data were organized into an evidence matrix, categorized by five key EIP development stages: initiation, planning, implementation, evaluation, and characterization.

Data collection and analysis

Primary data collection took place from January 2024 to December 2025, using semi-structured interviews and structured questionnaires administered to the same group of stakeholders. A total of 17 informants were chosen through purposive sampling to participate in both the interviews and the questionnaire sessions. The participant group included regulators from the MoI, representatives from the Indonesian

Fig. 1. *Research methodology framework*



Industrial Estate (IE) Association (HKI), and park managers from various estates, including the three pilot sites (MM 2100, Karawang International Industrial City, and Batamindo), as well as Wijayakusuma Industrial Park (IP), Nusantara IP, Medan IP, Batang Integrated IE, Surabaya IE Rungkut, and Java Integrated Industrial and Ports Estate. Both tools assessed factors across three strategic areas: (1) resource circulation strategies; (2) ecological environmental development; and (3) collaborative frameworks. At the same time, field observations were carried out at these industrial estates. These visits included inspections of facilities related to IS, renewable energy, and environmental management, and discussions with park representatives.

To triangulate the data, the dataset was analyzed using two qualitative methods that reflect the nature of the sources. Data from structured questionnaires and official documents were content-analyzed for policy mandates, regulatory frameworks, and stakeholder responses. Meanwhile, insights from semi-structured interviews and field observations were thematically analyzed to identify patterns in institutional dynamics, regulatory friction, and practical issues. This approach enabled comparison among formal policies, field realities, and stakeholder experiences. The roadmap and recommendations were then developed by analyzing the gaps between regulations and implementation challenges. Finally, expert judgment and Focus Group Discussions (FGD) with researchers, specialists, and officials from MoI validated the model and contextualized recommendations within Indonesia's socio-technical environment. A key step in shaping the domestic model is comparing global and local standards using international standards, UNIDO tools, and relevant frameworks to ensure relevance and competitiveness. Findings from the analysis and comparison lead to two main outputs: first, the Indonesian EIP model characterization detailing its structure, challenges, financing, and enabling factors; second, a practical roadmap outlining standards, pilot projects, implementation steps, monitoring, evaluation, and guidance for EIP development. The next step is to implement a roadmap aligned with Indonesia's EIP characteristics to produce a final, practical model.

Results and Discussion

Institutional and policy architecture

Based on our formal document review, the development of environmentally conscious industrial zones in Indonesia is anchored in cross-sectoral regulations. The foundational framework is Law No. 3/2014 on Industry which mandates the application of green industry principles to ensure sustainable resource efficiency and deliver socio-economic benefits to the

community (GoI, 2014; Mamuja and Setiawan, 2023). This policy direction is advanced by Government Regulation (GR) No. 20/2024 on Industrial Zoning. It explicitly defines an EIP as a zone integrating sustainability across all developmental stages, from site selection to area management, to optimize spatial planning and mitigate environmental impacts (Fitrianto et al., 2020; GoI, 2016, 2024). However, while this regulatory framework establishes a robust theoretical baseline, our primary data reveals a critical translation gap. During semi-structured interviews, park managers from the pilot estates emphasized that these broad statutory definitions of 'sustainability' currently lack the precise technical guidelines required for practical, on-the-ground implementation.

Operationally, energy efficiency and integrated licensing serve as the foundation of EIP (Sulaiman et al., 2008) Theoretically, frameworks such as Law No. 30/2007 on Energy and GR No. 20/2024 ensure sustainable utilization by mandating the integration of Environmental Impact Assessments with electronic building approvals (PBG) to prevent ecosystem damage (GoI, 2007, 2024; Widya et al., 2019). However, literature warns that overlapping regulations frequently impede practical application (Eliza et al., 2016). Validating this academic observation, our empirical data from HKI representatives revealed that navigating this integrated permit system frequently triggers administrative bottlenecks due to misaligned priorities between national energy targets and regional environmental standards

Institutionally, our policy mapping identifies four primary stakeholders: the MoI (regulator), the MoE (environmental supervision), the Ministry of Energy and Mineral Resources (clean energy transition), and the Regional Governments (spatial designation). Despite this structured division, our thematic analysis of interview data reveals that overlapping jurisdiction, particularly in environmental supervision and green infrastructure financing, lead to severe compliance fatigue among industrial tenants. This friction epitomizes the aforementioned 'ego-sectoral' behavior. Consequently, addressing these institutional bottlenecks requires more than new regulations. It necessitates optimizing cross-ministerial coordination to actively bridge national mandates with decentralized regional implementation, thereby ensuring a consistent and measurable EIP transition.

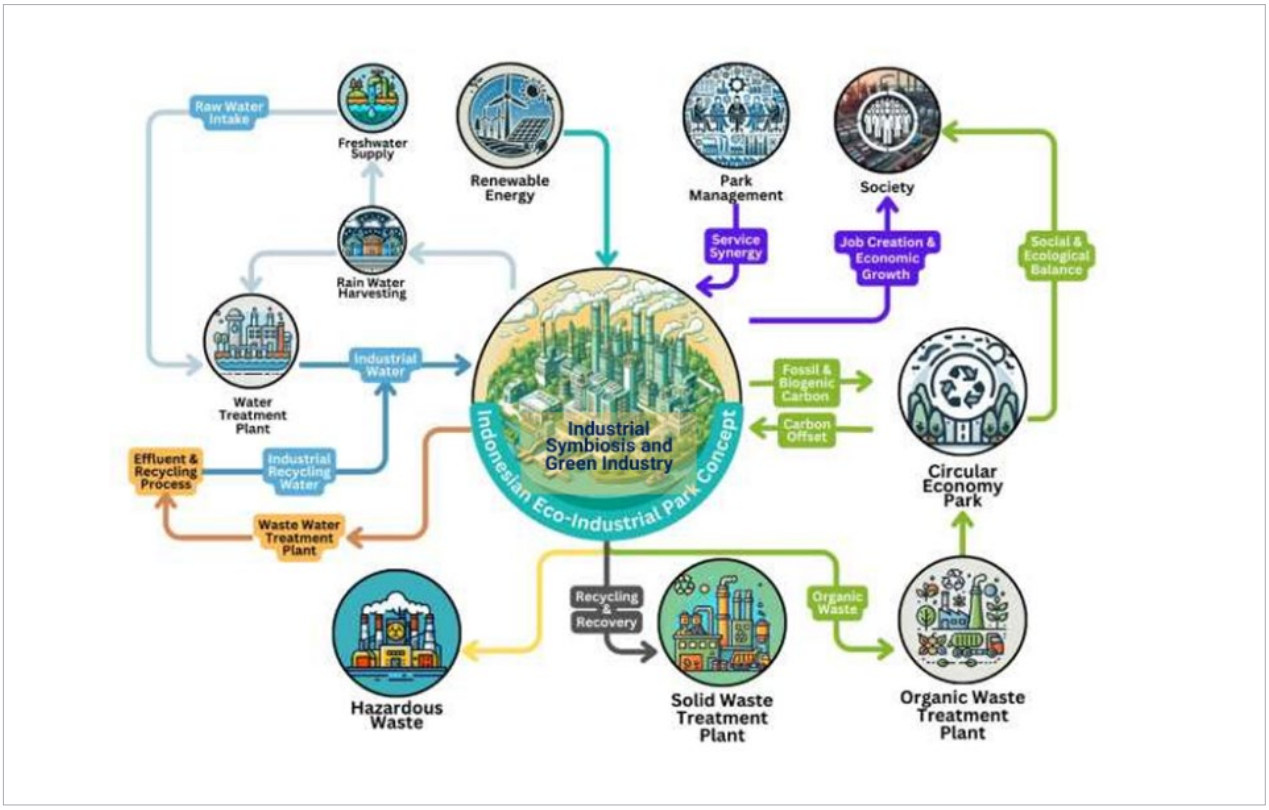
Implementation strategy of national EIP projects in Indonesia

Based on our historical policy review, the implementation strategy and enabling mechanisms are fundamental to resource allocation and stakeholder coordination for EIP development in Indonesia. The historical trajectory of IPs in Indonesia reveals a significant shift in governance. Initially established in the 1970s by state-owned enterprises to attract capital (with the Jakarta Industrial Estate Pulo Gadung/JIEP in 1973), the management landscape was later decentralized by Presidential Decree 53/1989 (GoI, 1989), thereby allowing private-sector dominance. This evolution is critical because, as mandated later by Government Regulation 142/2015 (GoI, 2015), the current push to enhance eco-friendly industrial competitiveness must now be implemented by a highly privatized and fragmented industrial estate sector, necessitating structured international support such as the UNIDO GEIPP.

To formalize this transition, the MoI issued Regulation No. 3174/2022 (GoI, 2022), establishing a Cross-Ministerial Forum involving 11 agencies to design and guide EIP implementation toward a net-zero emissions goal by 2050. Secondary literature, including UNIDO reports (UNIDO, 2023) this indicates that this journey is complicated by at least 40 overlapping national regulations that are not fully aligned with EIP policies. Our primary data validates and expands upon this documentary finding. During the semi-structured interviews, both park managers and HKI representatives explicitly cited this regulatory overlap as an operational barrier. Interviewees reported that while the central government proactively promotes EIP as a sustainable component, local and regional policies often lack the corresponding incentive and reward mechanisms, leaving industrial tenants confused regarding compliance standards. The concept of this national implementation strategy is captured in the Indonesian EIP framework (see *Fig. 2*).

From a policy analysis perspective, this framework offers a holistic vision that integrates IS and principles of the circular economy. It maps the ideal sustainable management of resources, illustrating how freshwater dependency is reduced through rainwater harvesting and wastewater recycling, while solid and hazardous wastes are looped back into productive use at dedicated treatment facilities. However, synthesizing this theoretical

Fig. 2. *National Indonesian EIP framework*



framework with our field observations reveals a significant "policy-practice gap." While the chart presents a seamless integration of renewable energy, carbon management, and waste-to-resource loops, our empirical observations at the pilot sites indicate that executing these physical exchanges is heavily constrained. For instance, the idealized loop for hazardous waste recycling depicted in the framework often conflicts with strict, classified local environmental permits that restrict the physical transfer of by-products among diverse firms. Therefore, this study argues that while *Fig. 2* successfully provides a normative blueprint for sustainable industrial development, its practical realization requires the central government to transition from merely designing ideal flowcharts to actively dismantling the localized regulatory barriers that prevent physical IS.

Implication of Indonesian EIP projects (2021–present)

Evidence from the implementation of EIPs in South Korea and China demonstrates that IS can significantly reduce production costs and environmental emissions. In South Korea, the National EIP program run by the Korea Industrial Complex Corporation (KICOX) since 2003 has shown tangible results. This program has resulted in energy savings of 1.35 million tonnes of oil equivalent (toe), a reduction of 6.48 million tonnes of CO_2 emissions, and a reduction of 1.09 million tonnes of toxic gases (SOx and NOx). In addition, 5.21 million tonnes of waste and by-products were successfully reused, generating an economic value of 1.848 trillion Korean Won (KRW) (≈ $1.68 billion) through cost savings and by-product sales via the IS system. Socio-economically, this program created 848 new jobs and 56 patents(Kim, 2017; Park et al., 2016). Meanwhile, in China, a case study in the Tianjin Economic and Technological Development Area shows that the 2010–2013 IS program reduced CO_2 emissions by 89,355 tonnes, diverted 321,076 tonnes of waste from landfills, and increased revenue by RMB 110.4 million. The technological transition from Cathode Ray Tube to Thin Film Transistor-LCD reduced water consumption by 94%, wastewater emissions by 96%, and hazardous waste by 99%, accompanied by a nearly threefold

increase in regional GDP during the period 2006–2012 (Shi and Yu, 2014). These two experiences demonstrate that the EIP concept is not only an environmental management instrument but also an economic strategy that can increase resource efficiency, reduce production costs, and strengthen industrial competitiveness in the long term.

GEIPP is a significant initiative funded by the Swiss State Secretariat for Economic Affairs (SECO) and implemented by UNIDO. The program aims to facilitate the transition of conventional industrial zones into EIPs in developing countries. During Phase I of GEIPP, UNIDO selected seven countries as pilot projects for EIPs: Colombia, Egypt, Peru, Ukraine, Vietnam, South Africa, and Indonesia. In Indonesia, three IPs were selected by UNIDO and the MoI as pilot projects, namely MM 2100 IP, KIIC, and Batamindo IP, as part of the GEIPP Phase I (2020–2023) (UNIDO, 2024). This phase aims to achieve two key outcomes: 1) EIPs will be incentivized and integrated into relevant policies and regulations, and 20 Opportunities for EIPs will be identified, and implementation will begin, with confirmed environmental, economic, and social benefits for enterprises. As a result of Phase I, 70 entities in Indonesia have been successfully mapped, including 11 government agencies involved in the formulation of EIP policies. The initiative has also assessed the level of interest and capability of these entities to influence the use of EIP policy tools. Furthermore, 39 regulations related to EIP development have been identified. GEIPP (2024) also reported the economic and environmental benefits of implementing Phase I (MoI and UNIDO, 2023).

GEIPP Phase I in Indonesia (July 2020 to December 2023) includes three pilot projects promoting sustainability, with a $1.96 million investment. The projects achieved a 12,642-tonne annual reduction in CO_2 emissions, saved 18,464 MWh of electricity and 48,092 GJ of thermal energy, reduced water use by 119,902 cubic meters, and used 99 tonnes of materials. They generate about 621 MWh of renewable energy annually, supporting Indonesia's renewable energy goals. Results, documented and reported, show the program's progress and impact. Despite a $1.96 million investment, the projects save $1.53 million annually, demonstrating efficiency gains and highlighting the economic and environmental benefits of the EIP approach (MoI and UNIDO, 2023; Susan et al., 2024)

GEIPP-Indonesia Phase II (January 2024 to December 2028) involves pilot projects in five industrial estates, including the Medan Industrial Estate and Greenland International Industrial Center-Deltamas. The initiative promotes EIP approaches to boost resource efficiency, reduce waste, encourage recycling, and enhance economic, environmental, and social performance, supporting inclusive, sustainable industrial development within Indonesia's circular economy. From January to October 2024, five pilot projects invested about $7.75 million, achieving significant environmental benefits: a reduction of 10,217 tonnes of CO_2 equivalent, a saving of 12,184 MWh of electricity, and the production of 60 tonnes of materials, along with 3878 MWh of renewable energy. Financial savings reached $1.35 million. These results underscore the ongoing progress and positive impact of Phase II (Dutt, 2025; UNIDO, 2023; UNIDO et al., 2024). Overall, data from both phases show that investment in EIP provides substantial financial and environmental benefits, i.e., successfully mapping 70 entities, identifying 39 EIP-related regulations, and demonstrating that the EIP concept is a viable model for sustainable and inclusive industrial development in Indonesia (UNIDO et al., 2024).

Characterization of Indonesian EIP projects

To strategically design Indonesia's EIP transition, it is essential to draw insights from established international success stories. Evaluating the operational models of countries like Korea, the Netherlands, and the USA provides valuable benchmarks for resource allocation, stakeholder coordination, and capacity-building. A previous study within the Indonesian EIP Blueprint identified that extensive industrial estates, natural resources, and growing awareness of the Sustainable Development Goals (SDGs) act as key domestic drivers; however, unlocking this potential requires overcoming the absence of specific policy guidelines and fragmented governance (Tamtomo et al., 2025). Furthermore, integrating existing national initiatives, such as the Resource Efficiency and Cleaner Production (RECP) program implemented by the MoI and UNIDO, is crucial for fostering early-stage implementation. The evolution of these international EIP models, spanning the initiation, planning, implementation, and evaluation stages, is comprehensively characterized and compared with the current Indonesian context in *Table 1*.

Table 1. *EIP characteristics comparison between Indonesia and other countries*

Characteristics	Indonesia	Korea	Netherlands	USA
Initiation stage				
Project	Environmentally Conscious IP (EIP)	EIP	Rotterdam Harbour and Industry Complex, multi-year IE System programme	Fairfield (Baltimore), Brownsville Regional IP
Development model	EIP transition	EIP transition	Green Field	Brown field
Planning stage				
Project goal	RECP	Resource efficiency, environmental protection, industrial growth, economic progress, and competitiveness.	Resource Sharing, waste reutilization, and Infrastructure integration	Primarily, the creation of family-wage jobs; economic factor valued as more important than the environmental factor
Applicant	MoI, Ministry of National Development Planning.	Local government	Ministry of Economic Affairs and Climate Policy, Regional Harbor Authority, Regional Environmental Protection Agency (EPA)	Local and regional governments, the EPA and the Department of Energy
National policy	Draft Regulation Considering EIP by the MoI	Green growth; National EIP masterplan	Official national policy since 1997; the government provides financial and expert advice through agencies like Novem	National initiatives by the President's Council on SD and EPA face regulatory barriers, such as the Resource Conservation and Recovery Act.
Key drivers	EIP label	IS benefits	IS benefits: balancing economic and environmental factors	Availability of substantial government funds; presence of "anchor tenants" to foster alignment
Duration	2021-present	2005–2016	Multi-year programmes (e.g., Rotterdam's INES programme started in 1994 and evolved)	Planned for a relatively short period of 5-10 years, compared to organic models
Implementation stage				
Financial Instrument Regulation	Subsidy scheme	IS feasibility support (central government 70%, local government 20%, private participation 10%) Strengthening Environmental Standards	A planning subsidy scheme shares costs equally between companies and the government, with companies typically paying implementation costs unless subsidies are given	Substantial government grants (e.g., from the EPA, Economic Development Administration, and other funding streams; the government bears planning costs
Enabling mechanism of the business model	UNIDO model	Private sector investment; PPP project (Energy Service Company (ESCO); Water saving company green fund)	UNIDO model - PPP projects; private sector investment; public and private entities (e.g., ESCOs)	Government-led initiatives; existence of anchor tenants; efforts to overcome regulatory barriers
Evaluation stage				
Evaluation	Under creation by the Indonesian MoI	Ministry of Trade, Industry and Energy publishes the economic, environmental, and social performance annually based on the evaluation criteria	Economic, environmental, and social performance are published annually by officials, based on analysis of "sustainability capabilities"	Methodologies include ecological risk assessment framework developed by the US EPA and Life Cycle Assessment

Source: (Chertow, 2007; Heeres et al., 2004; van Beers et al., 2020).

Challenges

The successful large-scale implementation of the EIP framework in Indonesia faces multifaceted systemic and operational hurdles that hinder its complete application across existing industrial zones. A significant challenge lies in the varying levels of readiness and acceptance among industrial estate managers and tenants, leading to inconsistent adoption and coordination. This operational difficulty is further exacerbated by the inherent complexity of retrofitting older estates; those with an occupancy rate above 50% that were not initially designed for EIP principles find it exceptionally difficult to reorient their infrastructure and processes. Furthermore, the framework's expansion is undermined by low public awareness of the EIP concept among surrounding communities. At the same time, industrial tenants remain concerned about the financial viability, specifically the potential for rent increases associated with integrated services.

The most critical barrier to unified EIP development stems from pervasive regulatory and governance deficiencies. Currently, the GoI and HKI have failed to establish specific regulations or dedicated development guidelines for the EIP framework, creating a policy vacuum. The successful execution of EIP requires extensive regulatory harmony and alignment across numerous existing policies, yet this collaboration is complicated by disjointed oversight. The planning, implementation, and monitoring of industrial estates remain sectoral, with various ministries and institutions operating independently. This fractured approach leads to confusing guidance for managers and tenants and fosters "ego-sectoral" behavior, where conflicting or uncoordinated regulations actively obstruct the comprehensive, integrated development required by the EIP model.

Finally, the efficacy of the EIP framework is challenged by concerns regarding its suitability and evidence base within the local context. The current reliance on the UNIDO framework is problematic, as it has not been subjected to a dedicated review for Indonesia and therefore lacks the necessary evidence-based support tailored to the nation's unique industrial landscape, regulatory structure, and environmental realities. Without a localized assessment and adaptation of the framework, efforts to mandate or scale its implementation will likely continue to meet resistance and difficulty, ultimately preventing the realization of a fully integrated national EIP network.

Financial scheme

According to the existing literature, the financial landscape for EIP development is universally characterized by high upfront capital requirements and long payback periods, which often discourage private-sector participation (Lavitt and Sargeant, 2025). In developing countries, the economic value of green infrastructure remains difficult to quantify, making it challenging to reach financial closure without targeted interventions like credit enhancements or green bonds (Pasquini and Enqvist, 2019). While PPPs have emerged as a strategic vehicle for sharing financing risks and fostering innovation (Owojori and Erasmus, 2025; Vassileva, 2022), their success is deeply contingent upon strong institutional capacity and precise accountability mechanisms, areas where many developing nations still struggle (Akomea-Frimpong et al., 2022).

To bridge this gap, our policy review indicates that the Indonesian government has attempted to mobilize diverse funding streams, ranging from fiscal incentives and basic infrastructure provision to the implementation of a national Green Taxonomy (Safitri and Syaipudin, 2025; GoI, 2024) This taxonomy serves as a critical intermediary, aligning EIP management needs with the growing demand for green investment opportunities (Arlyana Abubakar et al., 2025). Simultaneously, development assistance from international financial institutions remains a primary source of concessional funding. Our mapping identifies a broad spectrum of global financiers supporting Indonesia's EIP transition, encompassing multilateral entities (e.g., the World Bank Group, Asian Development Bank), bilateral institutions (e.g., KfW development bank, USAID, Dutch FMO), and thematic climate funds (e.g., Global Environment Facility, the European Union SWITCH-Asia Proggramme). These organizations provide essential soft loans, grants, and equity financing targeted at resource efficiency and renewable energy initiatives.

Combining financial mapping with findings shows that local stakeholders depend heavily on international aid. While organizations like UNIDO provide initial capital, qualitative research highlights a systemic lack of local institutional readiness. Park managers in interviews noted that the transition from donor-funded pilot projects to a sustainable green investment market is

Table 2. *Comparative analysis of UNIDO and the Indonesian EIP framework*

UNIDO EIP (International framework)	Indonesian regulations (Green industry standards and industrial estates)	Difference of focus and localization
Aspect I: Economics (GoI, 2018; World Bank, 2021)		
Economic performance: • Improved economic value, reduced operational costs via resource efficiency, and enhanced access to green finance. • Support for SMEs and integration within the value chain.	• Efficient use of energy, raw materials, and water is the primary technical aspect of green industry standards to reduce production costs. • Provision of fiscal and non-fiscal facilities for companies certified for green industry.	UNIDO advocates a comprehensive, strategic approach covering supply and value chains, while Indonesia focuses on targeted, measurable goals, such as improving input efficiency, mass, energy, and water use, and strengthening government incentives.
Aspect II: Social (GoI, 2018; van Beers et al., 2020)		
Social performance: • Provision of social infrastructure (e.g., health/training facilities) for workers. • Creation of decent jobs. • -Structured community dialogue and grievance mechanisms.	Employment and corporate social responsibility (CSR): • Fulfillment of CSR and employment criteria as aspects of green industry standards management. • Compliance with labour laws and regulations.	UNIDO advocates a holistic approach that focuses on workers' quality of life and community conflict resolution, while Indonesia emphasizes regulatory compliance with labor laws and CSR reporting.
A*spect III: Environment* (MoI, Green Industry Standards (various sectors) (UNIDO, 2017)		
Beyond compliance focus: • IS (exchange of waste, water, and energy between companies) is a high-level criterion that must be achieved. • Waste, water, energy, and climate resilience management that exceeds national standards.	Compliance and technical green industry standards: • Compliance with environmental quality standards (Mandatory). • Technical criteria for green industry standards include limits on greenhouse gas (GHG) emissions, waste management, water efficiency, and sustainable production to minimize environmental impact.	UNIDO emphasizes detailed, proactive ecological collaboration and outperforming standards. Indonesia's approach is industry-specific, focusing on efficiency and quality targets set by the government.
Aspect IV: Area management (UNIDO, 2020; GoI, 2024)		
Park management performance: • Active role in managing IS and centralized services. • Incorporate EIP planning and design from the beginning. • Continuous EIP performance monitoring.	Developer Obligations: • The obligation of an industrial estate company to provide infrastructure and environmental management facilities. • Tenants must follow industrial area rules; the estate company manages compliance.	UNIDO emphasizes facilitation and promoting collaborative innovation, while Indonesia focuses on spatial planning, infrastructure, and regional legal compliance.

slowed by the scarcity of local financial intermediaries capable of assessing long-term risks associated with IS. HKI responses confirmed a 'wait-and-see' attitude among local private investors, who see high upfront costs as regulatory risks despite PPP frameworks. To ensure the long-term sustainability of EIPs in Indonesia, the government must not only support international grants but also reduce investment risks with targeted guarantees to build local confidence.

Enabling mechanism

Based on our mapping of policies, Indonesia's National EIP Project, led by a collaboration between the MoI, UNIDO, and various national stakeholders as part of the GEIPP program, creates a supportive environment for industries to grow sustainably. This aligns with Government Regulation No. 20/2024 (GoI, 2024), which is supported by a framework comprising three key components. The first component involves institutional

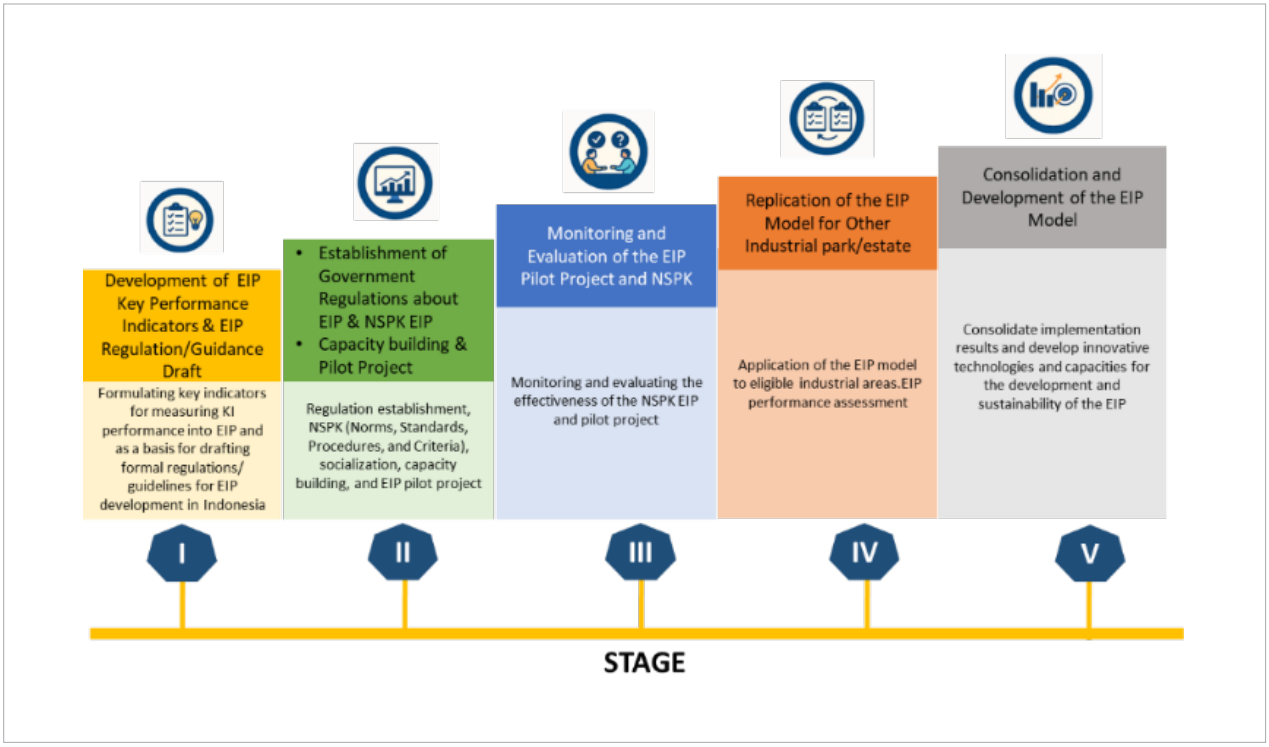
coordination through the Cross-Ministerial Forum for EIP Acceleration, which brings together eleven ministries and agencies to harmonize EG and spatial planning. This approach aims to minimize regulatory fragmentation, following the principles of integrated frameworks, as in Lyovkina et al. (2022).

While this top-down structure secures high-level political support, our analysis shows it also introduces bureaucratic layers. The mechanism should shift toward a more decentralized approach to address these "ego-sectoral" gaps. This would allow regional bodies to adopt and implement cross-sectoral directives as local rules independently. Additionally, there is the question of financial facilitation, which involves mechanisms such as PPPs, various green financing options, and the national green taxonomy to encourage investment. This lowers economic risks linked to green initiatives and offers incentives to produce goods that use fewer resources and emit less carbon, as in Halonen and Seppänen (2019). Third, technical capacity-building focuses on enhancing the skills of estate managers and tenants through specialized training and knowledge-sharing platforms. These efforts are supported by digital monitoring, accessible environmental facilities, and strong data management systems, significantly improving cross-sector cooperation and operational efficiency. This approach highlights the importance of adaptive governance through continuous monitoring and benchmarking. By customizing UNIDO's global performance standards and their indicators, covering energy efficiency, water use, waste reduction, and social inclusion, to fit Indonesia's specific context, the country adopts a hybrid regulatory model. This approach balances adherence to international standards with addressing local policy needs and administrative structures. Overall, this is a positive development.

Comparison of the global standard with the local standard

A comparative analysis of EIP assessment across four core dimensions, economic, social, environmental, and area management, reveals fundamental differences between the UNIDO international framework and current Indonesian policies. As summarized in *Table 2*, UNIDO generally adopts a proactive, holistic, and globally strategic 'beyond compliance' approach (Mozaleva et al., 2023; World Bank, 2021). In contrast, Indonesia's

Fig. 3. *Indonesia EIP roadmap, prepared by the authors*



localized framework is heavily oriented toward reactive, segmented, and mandatory regulatory compliance (GoI, 2018, 2024; Hasjanah, 2025). This distinct disparity highlights the critical need for a strategic bridging mechanism. To harness the transformative potential of the EIP, Indonesia must establish a hybrid regulatory framework that effectively integrates the comprehensive international standards of collaborative innovation and IS with strict domestic legal mandates.

Roadmap

The roadmap for EIP in Indonesia outlines a five-stage process to promote sustainable industrial development (see *Fig. 3*). Stage I focuses on developing key performance indicators (KPIs) for EIP and drafting regulations/guidance, incorporating stakeholder participation to measure IPs' performance as a basis for formal EIP guidelines. This stage has been completed, with indicators integrated through collaborative input and the regulation draft finalized.

Currently, Indonesia is in Stage II, working on government regulations for EIP and Norms, Standards, Procedures, and Criteria (NSPK). This includes ongoing capacity building, pilot projects conducted by the government or associations across multiple IPs, similar to UNIDO's approach through its concept for various IPs in the GEIPP. It also involves developing regulations, socialization efforts, and key implementation steps. The process to formally establish the regulation is underway, and it will be shared with all stakeholders, especially those in IPs, to ensure widespread adoption.

Subsequent stages expand on this foundation: Stage III focuses on monitoring and evaluating the effectiveness of the EIP pilot projects and NSPK. Stage IV involves replicating the EIP model in other IPs or estates, with performance assessments for eligible regions. Finally, Stage V consolidates the results and fosters new technologies and capacities to support the ongoing development of the EIP model.

Conclusions and Recommendations

Indonesia's EIP development balances industry growth with environmental sustainability. Since the 2021 GEIPP pilot projects, efforts have shown resource conservation, emission reduction, and efficiency gains. The program is in the early stages, mainly limited by systemic challenges rather than technology. Findings reveal fragmented governance and gaps that hinder adoption. High-level regulations exist, but the lack of technical guidelines causes confusion among estate managers and tenants. Dispersed oversight across ministries and 'ego-sectoral' behaviors worsens policy implementation. Local resistance to adapting EIP in industrial estates stems from costs and stakeholder concerns, limiting voluntary participation. To succeed, Indonesia must move from theory to practical, integrated implementation, strengthening supervisory agencies' capacity for cross-sector coordination and performance monitoring. Developing comprehensive operational guidelines and fostering stakeholder engagement can help turn industrial estates into sustainable, competitive ecosystems.

To accelerate Indonesia's EIP transition, the country needs a multi-pronged strategy. Key steps include institutionalizing stakeholder collaboration through regular inter-ministerial forums and establishing an 'EIP Center' to provide technical support, facilitate public consultations, and build capacity for estate managers and tenants. Integrating initiatives such as the circular economy and RECP programs into a unified EIP framework reduces regulatory overlap, aligns policies, and promotes the exchange of best practices across sectors. Success depends on deploying a digital Monitoring and Evaluation system to track impacts such as energy savings, emissions, and waste in real time, ensuring transparent reporting and adaptive policies. This combined approach of coordination, program integration, and rigorous evaluation will help Indonesia scale isolated projects into a comprehensive EIP ecosystem.

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