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Strategies for Improving the Regenerative Performance of the Pancoh Ecotourism Village Master Plan through a Circular Economy Approach

Tiara Dita Melindasari^{1*}, Jessica Fitriani Putri², Anna Pudianti³, Vincentia Reni Vitasurya⁴

^{1,2}Master's student in Architecture, Atma Jaya University, Yogyakarta, Indonesia

^{3,4}Lecturer, Department of Architecture, Atma Jaya University, Yogyakarta, Indonesia

*Correspondence: E-mail: raramelindasari328@gmail.com

ABSTRACT

The development of eco-tourism villages requires an approach that is not only sustainability-oriented but also capable of regeneratively enhancing the ecological capacity of the area. However, the application of circular economy principles in eco-tourism village master plans has not yet been optimally integrated. This study aims to evaluate the baseline regenerative performance of the Pancoh Ecotourism Village master plan based on circular economy indicators and to formulate improvement strategies toward a more circular regional system. The research method employs a mixed-methods approach through observation, document analysis, interviews, and analysis of the Circular Economy Index (CEI) based on indicators of local materials, material reuse, waste management, and material efficiency. The results show a CEI value of 44.25%, indicating a transitional stage toward a regenerative system. This value is supported by high levels of local material use and the waste circular index, but remains low in material reuse and material efficiency. A simulation of improvement strategies indicates an increase in the CEI value to 54.29%, suggesting a more circular regional system that is approaching a regenerative state.

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1. INTRODUCTION

In recent decades, the tourism sector has grown rapidly as one of the main drivers of the global and regional economy, including in rural areas. The World Tourism Organization notes that the tourism sector contributes approximately 10% to global Gross Domestic Product (GDP) and provides one in ten jobs worldwide, making it a strategic sector in regional development (United Nations World Tourism Organization (UNWTO), 2021). In the context of sustainable development, rural tourism has emerged as a strategic approach that not only drives local economic growth but also strengthens environmental and cultural conservation through community engagement (Lane & Kastenholz, 2015; Lowry, 2017).

In Indonesia, tourism villages have become a key strategy in community-based tourism development. The government, through the Ministry of Tourism and Creative Economy, actively promotes the development of tourism villages as an effort to improve community welfare while preserving local character in rural areas. The Special Region of Yogyakarta is one of the areas with significant development of tourism villages, where management is not only focused on increasing the number of tourist visits but also on community empowerment, cultural preservation, and the sustainable utilization of environmental potential (Bappeda, 2022). This underscores that tourism villages function as socio-ecological systems that simultaneously integrate economic, social, and environmental dimensions. However, in practice, there is often a mismatch between planning documents and existing conditions, resulting in suboptimal integration of environmental systems, local economies, and tourism activities - particularly regarding the implementation of circular economy principles.

As the discourse on sustainability in regional planning has evolved, a regenerative approach has emerged that emphasizes the sustainable restoration and enhancement of ecological and social systems' capacities (Mang & Reed, 2012). Unlike sustainability approaches that focus on reducing negative impacts, the regenerative approach views a region as a dynamic living system and aims to create positive impacts on the environment and communities (Plessis & Brandon, 2015). In the tourism sector, this approach has evolved through the concept of regenerative tourism, which emphasizes ecosystem restoration, the empowerment of local communities, and the creation of added value for tourist destinations (Radyahadi & Nurfara, 2024; Thakur et al., 2025).

The regenerative approach is closely linked to the principles of the circular economy, which focuses on resource efficiency through the use of local materials, optimization of reuse, waste management, and reduction of material consumption (Rodríguez et al., 2020). In the context of tourism areas, integrating circular economy principles is crucial because tourism activities involve high levels of material, energy, and water consumption. Therefore, implementing closed-loop systems in the development of tourism villages is necessary to create more efficient, adaptive, and regenerative regional systems.

One example of an environmentally - based tourism village is Pancoh Ecotourism Village, located in Turi Subdistrict, Sleman Regency, Special Region of Yogyakarta. This village has developed as a community-based tourism village with strong environmental potential through the integration of agricultural, plantation, livestock, and natural river landscape systems. The village's ecological character, dominated by rice fields and traditional water management systems, demonstrates the interconnection between residential activities, agriculture, and the environmental system. This potential makes Pancoh Village a relevant area for study within the context of circular economy and regenerative - based area development.

Despite its significant potential, the development of Pancoh Ecotourism Village still faces various challenges. Area development tends to focus on enhancing tourist attractions, while the integration of material systems, the environment, and tourism activities has not yet been fully realized in a systematic manner. Additionally, on-the-ground implementation indicates that resource utilization and area management are still carried out in a piecemeal fashion, resulting in suboptimal regenerative performance of the area. This situation indicates that the master plan document still requires enhancement strategies to foster the creation of a more circular and regenerative regional system.

Previous studies have discussed the application of regenerative concepts in the development of tourism and residential areas through the integration of environmental and local economic systems (Mang & Reed, 2012). Regenerative approaches have also been developed at the urban scale through the integration of environmental indicators such as energy, microclimate, ecology, and human well-being to create built environments that are more adaptive to climate change (Naboni et al., 2019). In the field of tourism, the concept of regenerative tourism emphasizes ecosystem restoration and the empowerment of local communities in the management of tourist destinations (Bellato et al., 2023; Dredge, 2022). However, research integrating a regenerative approach with circular economy indicators in the development of tourism villages in Indonesia remains relatively limited.

Therefore, this study offers a novel approach by developing strategies to enhance regenerative performance in the Pancoh Ecotourism Village master plan based on circular economy indicators. This study not only evaluates the alignment between the master plan and circular economy indicators but also formulates improvement strategies through the optimization of local materials, material reuse, material efficiency, and a closed-loop waste management system.

Thus, this study aims to evaluate the master plan document based on circular economy indicators to determine the baseline of the area's regenerative performance and formulate improvement strategies toward a more circular and regenerative system. This study is expected to contribute to the development of theory and practice in regenerative-based tourism village planning, as well as serve as a reference in the formulation of sustainable tourism policies in Indonesia.

2. LITERATURE REVIEW

The circular economy approach has emerged as a response to resource constraints and the increasing environmental impacts resulting from the linear economic system. The circular economy is defined as a system that is restorative and regenerative by design through the optimization of material reuse, repair, and recycling cycles to reduce waste and improve resource efficiency (Ellen MacArthur Foundation, 2015; Geissdoerfer et al., 2017). This concept emphasizes a shift from the take - make - dispose model toward a closed - loop system capable of maintaining material value over the long term (Kirchherr et al., 2017).

In the context of architecture and urban planning, the circular economy is not only about material management but also about understanding the area as a metabolic system involving flows of materials, energy, and human activities (Ghisellini et al., 2016) explains that the reduce, reuse, and recycle strategies are applied systematically across various scales, while the concept of urban metabolism views the area as an organism with measurable and optimizable input and output flows (Kennedy et al., 2011). Thus, the application of the circular economy in tourist areas emphasizes the comprehensive integration of material and resource systems.

In the development of tourism villages, circular economy principles can be applied by reusing waste as input for other activities, thereby forming a closed - loop material cycle. This aligns with the cradle – to - cradle concept, which keeps materials within biological and technical cycles without generating waste (McDonough & Braungart, 2002). Additionally, circular business model strategies, such as optimizing local resources and reusing materials, also hold potential for application within community - based tourism systems (Bocken, 2016).

To measure the level of circular economy achievement, the Ellen MacArthur Foundation (2015) developed the Material Circularity Indicator (MCI) as a quantitative indicator that evaluates the level of material circularity based on the use of new materials, non-recoverable waste, and material utility. (Linder et al., 2017)state that the MCI is effective in integrating various aspects of the material life cycle into a single value, while Pauliuk (Pauliuk, 2018) emphasizes its ability to support data-driven analysis and comparisons across scenarios. In this study, the MCI approach was developed into a Circular Economy Index (CEI) based on indicators of local materials, material reuse, waste management, and material efficiency to evaluate the baseline of a region's regenerative performance.

In a regenerative approach, the baseline serves as a critical stage for understanding the system's initial conditions before implementing design interventions and development strategies. (Dervishaj, 2024) explains that the baseline is the initial stage in operationalizing regenerative indicators and setting system improvement targets. Therefore, baseline evaluation not only serves to measure the area's level of circularity but also to identify gaps between existing conditions, the master plan, and the desired regenerative targets.

At the area scale, the circular economy encompasses not only material management but also the integration of ecological, social, and economic systems. (Murray et al., 2017) explain that the circular economy at the meso level involves coordination among actors and activities to form interconnected systems. This aligns with the concept of industrial ecology, which emphasizes symbiotic relationships among systems in the efficient use of resources (Graedel & Allenby, 2010).

Nevertheless, the circular economy does not yet fully reflect regenerative principles. Regenerative architecture emphasizes a system's ability not only to maintain but also to enhance environmental and social quality (Cole, 2015). Mang and Reed (2012) add that a regenerative approach requires a deep understanding of the relationships between humans, ecological systems, and local contexts. Therefore, the circular economy can be viewed as a transitional stage toward a more adaptive and restorative regenerative system (Plessis & Brandon, 2015).

Based on this framework, this study positions circular economy indicators as an evaluation tool to measure the baseline regenerative performance of the Pancoh Ecotourism Village Master Plan, as well as a foundation for formulating improvement strategies toward a more circular and regenerative regional system.

3. METHODOLOGY

This study employs a mixed-methods approach with evaluative and integrative perspectives to analyze the alignment between the master plan and circular economy indicators, as well as to formulate strategies for advancing toward a more circular and regenerative regional system in Pancoh Ecotourism Village, Turi Subdistrict, Sleman Regency.

Data collection was conducted through field observations, document reviews, and in-depth interviews with stakeholders, validated using source and method triangulation techniques. The evaluative approach was used to compare spatial functions, activity distributions, and material systems between the master plan and existing conditions, while

the integrative approach was used to identify interconnections among area systems within a regenerative framework. Area performance measurement was conducted using the Circular Economy Index (CEI) based on the principles of the Ellen MacArthur Foundation (2015), through four main indicators: Material Locality (ML), Input Reuse Material (IRM), Waste Circular Index (WCI), and Material Efficiency (ME).

CEI calculations were performed using an indicator scoring approach normalized as a percentage using the following formula:

$$CEI = \frac{\sum (w_i \cdot I_i)}{\sum w_i} \times 100\%$$

where I_i is the value of each indicator and W_i is the indicator weight. In this study, all four indicators were assigned equal weights to maintain the objectivity of the evaluation during the exploratory phase (Geissdoerfer et al., 2017; Kirchherr et al., 2017).

The assessment of each indicator is based on material composition and the area's system, using the following material weighting approach: local materials (1.0), locally reused materials (1.3), non-locally reused materials (1.2), new non-local materials (0.3), and semi-processed materials (0.4-0.5). This weighting scheme was developed in accordance with circular economy principles that prioritize material value retention, resource efficiency, and waste reduction (Ellen MacArthur Foundation, 2015; Linder et al., 2017).

CEI values are classified into three categories: low (<40%), moderate (40–70%), and high (>70%), representing performance levels toward a regenerative system. This classification is used to identify the area's position in the transition from a linear system to a circular-regenerative system.

This study sets a target for a minimum 10 - 15% improvement in regenerative performance from the baseline CEI value as an indicator of development success. This target is based on the principle of continuous improvement in the circular economy, which emphasizes gradual increases in resource efficiency and waste reduction (Geissdoerfer et al., 2017), as well as the concept of regenerative design, which focuses on progressively enhancing the adaptive capacity of socio-ecological systems (du Plessis, 2012; Mang & Reed, 2012).

Thus, this method serves not only as an evaluation tool but also as a foundation for formulating measurable and operational area development strategies based on a regenerative approach.

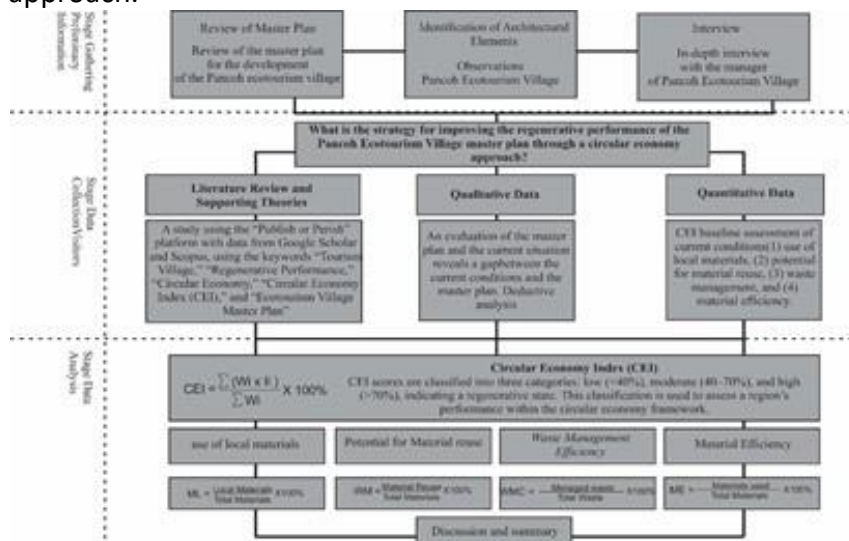


Figure 1. Research Methodology

Source: Author, 2026

4. RESULTS AND DISCUSSION

4.1. Research Site

In the Indonesian context, one example of the development of an eco-tourism village is Pancoh Eco-Tourism Village, located in Turi Subdistrict, Sleman Regency, Special Region of Yogyakarta (Figure 2). Covering an area of 44 hectares, Pancoh Village is known as a water catchment area, with the landscape dominated by plantations, agricultural land, and residential areas.



Figure 2. Map of Pancoh Ecotourism Village
Source: (Vitasurya et al., 2024)

Ecologically, Pancoh Village possesses environmental characteristics that support the development of nature-based ecotourism. The village landscape is dominated by rice fields, plantations, and river flows with relatively good water quality. Additionally, there is a reservoir that serves as a water source for community needs. Another unique feature is the presence of ponds in front of residents' homes and the use of the traditional *surthong* tool, which serves as both a water flow indicator and a pest repellent. These elements demonstrate the interconnection between the settlement system, agricultural activities, and water resource management in this village.



Figure (3) Riverbank Walk (4) Fishing (5) Batik Making (6) Camping (7) Salak Picking (8) Fish Farming.
Source: Pancoh Village Documents, Tourism Package (Published), 2012

Despite its significant potential, Pancoh Ecotourism Village faces challenges in post-pandemic visitor decline and the lack of integration among environmental, economic, and tourism systems, with development still focused primarily on enhancing attractions (Figures 3–8). In 2023, a masterplan was developed through collaboration with Atma Jaya Yogyakarta University under a community service program, involving stakeholders including students, local managers, the community, and the Sleman Tourism Office (Figure 9) (Vitasurya et al., 2024). The plan outlines key zones such as circulation, parking, main activity areas, and riverside trails.

The transformation of agricultural villages into ecotourism destinations represents an adaptive strategy that integrates local wisdom with economic development (I. Agusta, 2014). Pancoh Village demonstrates this through the use of local assets such as salak plantations, river trails, and traditional housing. However, the lack of system integration highlights the need for a regenerative evaluation to assess alignment between the masterplan and existing conditions and to identify opportunities for improving agro-ecotourism through circular economy principles.

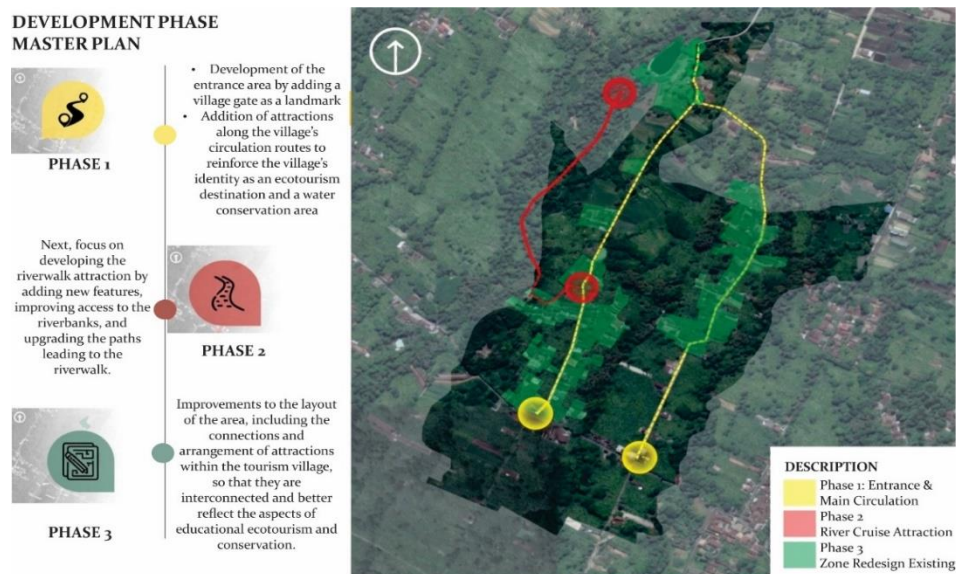


Figure 9. Map of Pancoh Ecotourism Village
Source: (Vitasurya et al., 2024)

4.2. Circular Economy Performance Analysis

The assessment of circular economy performance in this study employs the Circular Economy Index (CEI)(Ellen MacArthur Foundation, 2015) to evaluate regenerative capacity based on four indicators: local material use, reuse potential, waste management, and material efficiency. The analysis compares existing conditions with the masterplan to identify performance gaps. CEI calculations follow a coefficient-based approach (Figure 1), assigning values to material types, including non-local materials (0.3), local reuse (1.3), non-local reuse (1.2), new non-local materials (0.3), semi - processed materials (0.4 - 0.5), and reused non-local materials (0.6). This weighting reflects a normative preference for local and reusable materials; therefore, the evaluation integrates quantitative results with contextual interpretation to accurately represent the transition toward a regenerative agro - ecotourism system.

4.2.1. Analysis of Local Materials

The distribution of built-up areas in Pancoh Ecotourism Village indicates the potential for optimizing local resources in area development. Of the village's total area of 44 hectares

(440,000 m²), the main tourism area covers only 9,500 m² or approximately 1.98%, resulting in relatively low pressure on material usage. This condition presents an opportunity to utilize local materials such as bamboo and wood - which are renewable and locally available to support area development based on a circular economy (Kirchherr et al., 2017).

Table 1. Comparison of Built- Up Area and Material Composition in the Master Plan and Existing Conditions

No	Parameter	Master Plan		Eksisting	
		Value		Value	
		%	M ²	%	M ²
Area : 440.000 m ²					
1	Area of Main Tourist Attractions	1.98%	9500	1.98%	9500
2	Built-up Area	40%	3777	22%	2121.5
3	Local Materials	43.04%	1624	30%	636.45
4	Non-local materials	7.14%	264	7.69%	169

Source: Author, 2026

Based on the calculation results, the area of the planned tourism zone in the master plan reaches 9,500 m² or approximately 1.98% of the total village area (440,000 m²). At the planning stage, the proportion of built-up area reached 40% (3,777 m²), with the use of local materials at 43.04% (1,624 m²) and non-local materials at 7.14% (264 m²). This indicates that the master plan has prioritized the utilization of local resources in the development of the area.

By comparison, the existing conditions show that actual development implementation remains below the planned scenario (Figure 10). The proportion of built-up area in the current state is only 22% (2,121.5 m²), while the use of local materials has decreased to 30% (636.45 m²). On the other hand, the use of non- local materials remains relatively stable at 7.69% (169 m²). This indicates that the implementation of material strategies in the area has not yet fully aligned with the development direction outlined in the master plan.

Although the proportion of local materials in the master plan is relatively high, this does not automatically reflect the achievement of a circular economy. A circular economy emphasizes not only the use of local materials but also the integration of material cycles capable of maintaining material value within the usage system (Geissdoerfer et al., 2017). In the context of Pancoh Village, the use of local materials remains at the substitution stage and has not yet formed an integrated material circulation system, so material flows still tend to be linear.

When considered in relation to the area's spatial structure, the still-limited scale of development indicates that material flows within the area's system have not yet formed the complex area metabolism described in the concept of urban metabolism (Kennedy et al., 2011). Furthermore, from an industrial ecology perspective, material efficiency is determined not only by the type of material used but also by how that material is used, maintained, and returned to the system (Graedel & Allenby, 2010). Therefore, although Pancoh Village has high potential for local materials, the area's level of circularity remains low because it is not yet supported by integrated and sustainable material circulation mechanisms.



Figure 10. Comparison of master plan and existing materials

Source: Author, 2026

4.2.2. Analysis of Material Reuse

The analysis of material reuse in the Pancoh Tourism Village area was conducted by comparing existing conditions and development potential in the master plan based on the distribution of built-up areas. In the existing conditions, the application of material reuse is evident in the use of elements such as used tires and other natural materials; however, it remains limited to specific locations and has not yet formed a comprehensive system.

Table 2. Comparison of Local and Non-Local Reused Materials

No	Parameter	Master Plan		Eksisting	
		%	M ²	%	M ²
1	Built-up area	40%	3777	22%	2121.5
2	Local Material Reuse	1.90%	75.54	2.84%	59.4
3	Non-Local Material Reuse	0	0	6.00%	127.29

Source: Author, 2026

Based on a comparison between the master plan and the existing conditions, there are differences in the level of development and the utilization of reused materials. In the master plan, the proportion of built-up area is planned to be 40% (3,777 m²), whereas in the existing conditions, only 22% (2,121.5 m²) has been realized, indicating that the implementation of development remains below the planning scenario. In terms of material circularity, the use of local reused materials in the master plan, at 1.90% (75.54 m²), has increased to 2.84% (59.4 m²) in the current conditions. Additionally, the use of non-local reused materials at 6.00% (127.29 m²) has emerged, which was not planned in the master plan. This situation indicates adaptive efforts in utilizing used materials on-site, although they have not yet been integrated into the area's planning system.

However, this increase in the use of reused materials does not automatically reflect the achievement of a circular and regenerative system. Within the framework of the circular economy, a regenerative system emphasizes not only the reuse of materials but also the creation of a closed-loop material cycle capable of sustaining material value over the long

term (Ellen MacArthur Foundation, 2015). In the context of Pancoh Village, reuse practices remain partial and have not been integrated into the area's material system, so material flows still tend to be linear.

A regenerative approach also emphasizes the importance of systems capable of restoring, renewing, and improving the quality of resources sustainably. Therefore, strategies for improving the area must not only focus on increasing the quantity of material reuse but also on integrating material flows through a closed-loop system that encompasses the processes of use, maintenance, recovery, and sustainable reuse.

4.2.3. Analysis of Waste Management Efficiency

The Waste Management Efficiency (WME) analysis indicates that waste management in the master plan is not yet fully integrated into the circular economy system. Planning for material waste management remains limited and does not comprehensively cover reuse, recycling, or recovery strategies, so the area's material cycle has not been optimally established. As for the management of environmental waste from the eco-tourism village development planning document, see Table 3.

Table 3. Waste Management Efficiency Master Plan

Type of Waste	Amount of Waste	Source	Method Treatment	Track Output/Product	Principle
Used (used tires)	Area of the river trail entrance: 150 m ²	Manager's operations	Direct Reuse	Toward the riverbank	Reuse
	1 tire: 0.20 m ²				
	requires: 750				
	tires weighing 1,875 kg				
Cow manure	Number of cattle: 4 cows: 60 kg	Communal Shelter	Biogas and Compost	Gas energy and organic fertilizer	Circular
	manure/day 1 cow: 10–15 kg of manure/day				
	1 m ³ of biogas: 20–25 kg of manure				
	1 household: 1–2 m ³ /day				
Plastic waste	Number of visitors in 2025: 8,000 tourists/year. Average visits: 22 people/day	Tourists and daily activities	Creative recycling (Crafts)	Pots, decorative bags, and flowers	Recycle
	Based on standards (World Bank, 2018) and (Jenna et al., 2011),				
	tourist plastic waste production: 30–125 grams,				
	total 0.7–2.8 kg/day				
	total 4.5–18.75 kg/week				
	Waste management capacity is only 5 kg				

Source: Author, 2026

Based on the Waste Management Efficiency (WME) calculations in the planning document, 1,562 kg of waste was managed out of a total of 1,953.75 kg, leaving a residual of 388.75 kg. This figure indicates a WME achievement of 80%, suggesting that the majority of waste has been incorporated into the management scheme. Within the framework of the circular economy, this achievement is considered high, though it still needs improvement to

support residue minimization toward a zero - waste approach (Ellen MacArthur Foundation, 2015).

By comparison, the current situation shows a decline in waste management performance. Based on interview results, the waste bank is no longer operational due to weak institutional governance, while the biogas system developed since 2016 has also not been operating optimally due to funding constraints and limited cattle manure supply (BN, interview, July 5, 2023) (Ni et al., 2023). Additionally, biogas production requires the use of pure cow manure without any other materials mixed in, thereby limiting its implementation. This situation indicates that the effectiveness of WME is determined not only by planning aspects but also by the sustainability of governance, resource availability, and technological readiness.

Thus, although the master plan has demonstrated relatively high potential for waste management, on-the-ground implementation has not yet been able to establish a sustainable closed-loop system. This situation indicates that the area's regenerative performance in waste management still requires more systematically integrated improvement strategies.

4.2.4. Material Efficiency Analysis

The material efficiency analysis reveals a performance gap between the master plan and the existing conditions. At the planning stage, the material efficiency value was recorded at 52.08%, indicating a fairly high level of material efficiency but still falling within the transitional category toward a circular system. This achievement is dominated by the use of local materials at 43.04%, while the contribution of reused materials remains relatively low (1.90%), meaning material efficiency still relies heavily on the use of new resources.

By comparison, the existing conditions show a decrease in the material efficiency value to 46.53% (Table 4). Although the use of reused materials has increased, this has not been sufficient to offset the decline in the proportion of local materials to 30.00% and the increased use of non-local and new materials. This indicates that the implementation of the development has not yet fully succeeded in maintaining the material cycle efficiency as planned in the master plan.

Table 4. Comparison of Material Composition and Material Efficiency in the Master Plan and Existing Conditions

Material Type	Master Plan (%)	Existing (%)	Weight	Notes
Local Materials	43.04	30.00	1.0	Materials based on local resources
Non-local materials	7.14	7.69	0.3	Materials from outside the region
Local <i>Reused</i> Materials	1.90	2.84	1.3	Local recycled materials
Non-Local <i>Reused</i> Materials	0.00	6.00	1.2	Reuse of materials from outside
Material <i>Efficiency</i> (ME)	52.08	46.53		Percentage of utilized materials
Unused materials	43.75	49.30		Material residue (<i>waste</i>)

Source: Author, 2026

Within the framework of the circular economy, material efficiency is determined not only by the level of material use but also by the system's ability to maintain material value through the cycles of reuse, recycling, and reduction of new materials (Ellen MacArthur Foundation, 2015). Therefore, both the master plan (52.08%) and the existing conditions (46.53%) are still in the transition phase toward a circular system and have not yet reached the regenerative category (>70%). This situation indicates that increasing the use of local materials, optimizing

material reuse, and reducing dependence on new materials are key factors in the strategy to improve the area's regenerative performance.

4.3. Synthesis of the Area's Regenerative Performance

The synthesis of the area's regenerative performance in this study was conducted using the Material Circularity Indicator (MCI) approach from the Ellen MacArthur Foundation (2015) to evaluate the level of material circularity in the master plan and existing conditions. This approach considers aspects of local material use, material reuse, waste management, and material efficiency as the basis for determining the area's circular economy performance.

Table 5. Evaluation of Material Indicators within the Circular and Regenerative Economy Framework

Indicators	Baseline Conditions of the Master Plan	Existing Conditions	Target Ideal Regeneratif
Local Materials (LM)	43.04% (fairly high)	30% (fairly high)	>85%(predominantly local)
Reused Material (IRM)	1.90% (very low)	8.84% (very low)	>30–50%
Waste Circular Index (WCI)	80% (High)	0% (Very Low)	>80% (closed-loop system)
Material Efficiency (ME)	52.08% (moderate)	46.53% (adequate)	>80% (high efficiency)
CEI	44.25% (Transition)	17.08% (not yet circular)	>70% (Circular Regenerative)

Source: Author, 2026

The evaluation results indicate that the region's circular economy performance remains in the transition phase toward a regenerative system. Under the master plan, the proportion of local materials (ML) reached 43.04%, but decreased to 30.00% in the current condition. Meanwhile, material reuse (IRM) increased from 1.90% to 8.84%, yet it has not yet been able to form an optimal closed-loop material cycle. The most significant decline occurred in the waste circular index (WCI), which dropped from 80% to 0%, indicating that the waste management system is not functioning in the area's implementation. This condition also contributed to a decrease in material efficiency (ME) from 52.08% to 46.53%, meaning the area's material system remains dominated by a linear consumption pattern.

Overall, the CEI value in the master plan stands at 44.25%, while the current condition has dropped to 17.08%. This discrepancy indicates that the area's implementation has not yet fully maintained the circular economy performance as planned in the master plan. From an urban metabolism perspective, the area's material flows remain predominantly linear and have not yet formed an integrated closed-loop system. Therefore, improvement strategies focused on optimizing local materials and increasing material reuse are needed to drive the area's transition toward a more circular and regenerative system based on the master plan's baseline conditions.

4.4. Strategies for Improving Regenerative Performance

This study sets a target of at least a 10% improvement in regenerative performance from the CEI baseline value in the master plan as a benchmark for the area's improvement strategy. This target is based on baseline results indicating that the master plan's CEI value remains in the transitional phase toward a circular system and has not yet reached the regenerative category. In the principle of continuous improvement, the circular economy emphasizes gradual enhancement through resource efficiency, optimization of material cycles, and progressive waste reduction (Geissdoerfer et al., 2017). Furthermore, the regenerative design approach views area transformation as an adaptive process carried out gradually through the continuous enhancement of ecological capacity and system efficiency (du Plessis, 2012; Mang

& Reed, 2012). Therefore, this target is used to evaluate the effectiveness of the proposed strategies for improving regenerative performance (Table 6 and Table 7).

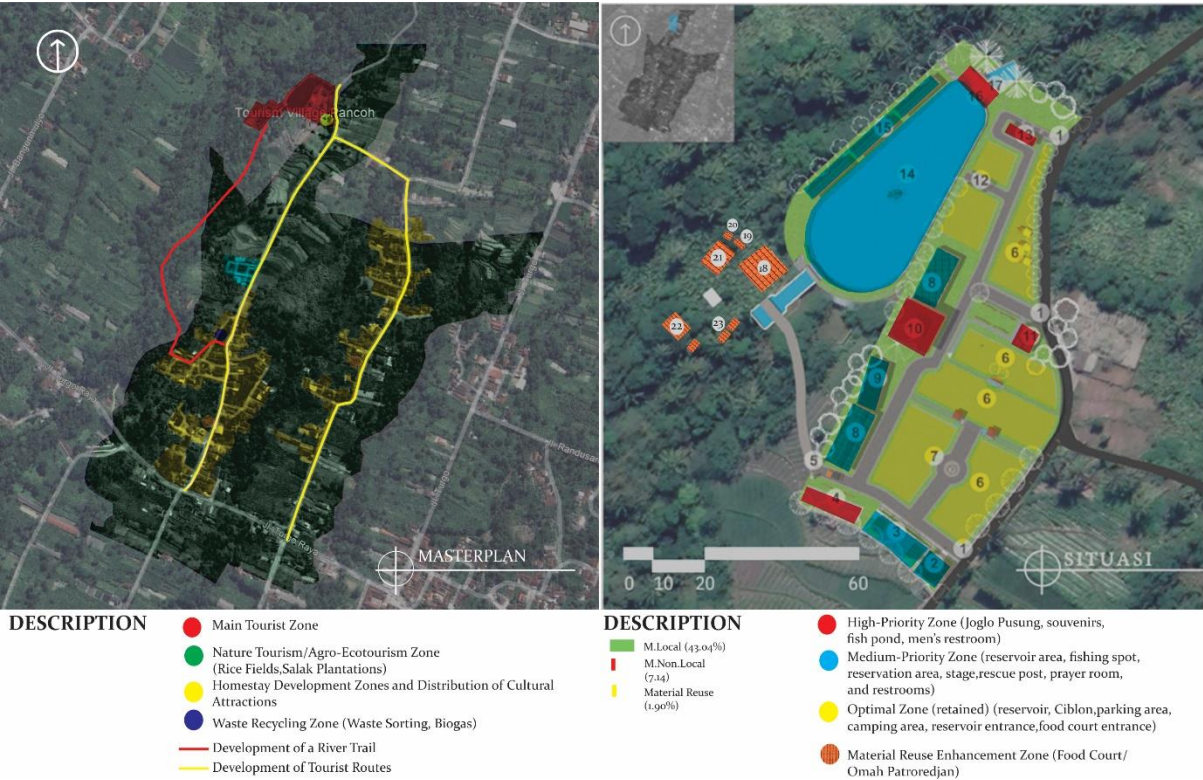
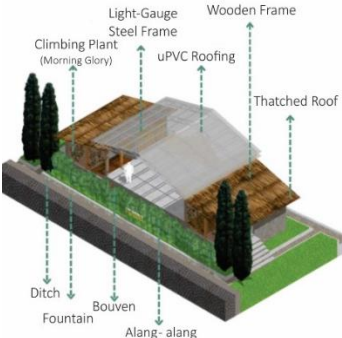
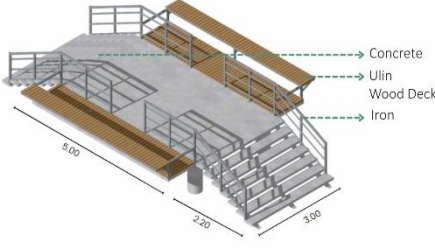
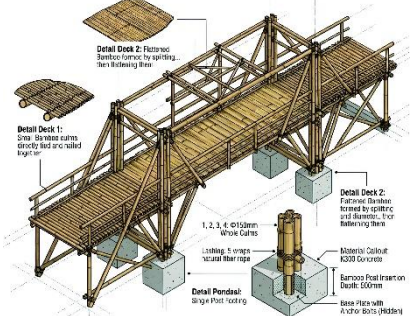


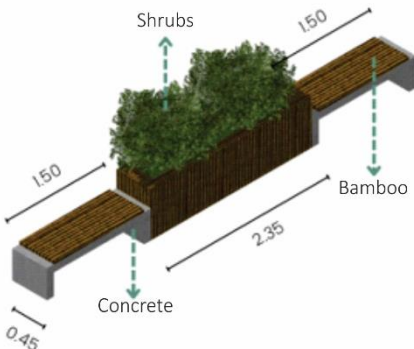
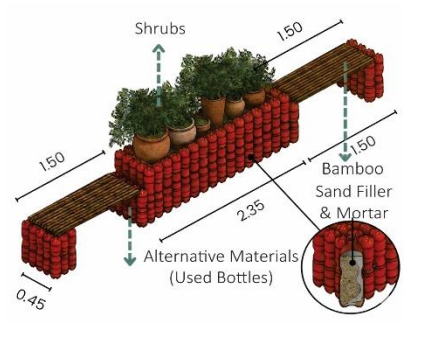
Figure 11. Circular Economy-Based Development Strategy for the Pancoh Tourism Village Area
Source: Author, 2026

Figure 11 illustrates strategies for enhancing the area’s regenerative performance at both macro and micro scales through the strengthening of a circular economy system based on priority zoning. At the micro scale, interventions focus on increasing the use of local materials, integrating material reuse, and developing closed-loop waste management systems in priority buildings and tourism facilities to support the transition toward a more circular and regenerative area system.

The strategy for improving the area’s regenerative performance focuses on high-priority and medium- priority zones through the optimization of local materials and material reuse, to increase the area’s CEI value toward a more circular and regenerative system, as shown in Table 6.

Table 6. Area Regenerative Performance Strategy

No	Improvement Strategy	Master Plan	Regenerative Improvement Strategy
1	ML Improvement	Light Steel Frame, UPVC, Rumbia Roof	Bamboo Frame, Rumbia Roof
	Stage		
2	ML Improvement	Concrete with natural stone veneer	Natural stone sourced from a local river
	Fish Pond Area		
3	ML Improvement	Concrete, Ulin Wood Deck, Steel	Bamboo Construction
	Reservoir Bridge		
4	ML and MR Improvement	Wood, Asbestos, Exposed Brick	Thatched Roof, Bamboo Construction
	Posko Resque & Balai Pertemuan		
5	ML and MR Improvement	Roof Tiles, Wood	Bamboo construction, walls made of woven salak leaves and used wood

No	Improvement Strategy	Master Plan	Regenerative Improvement Strategy
	Jonglo Pusung		
6	ML and MR Improvement	Bamboo and Concrete	Bamboo and Plastic Bottles Recycled
	Seating for Ponds and Reservoir Fishing		
7	MR Improvement	Bamboo	Reuse Enhancement Ornament Addition
	Entrance Wall Along the River		

Source: Author, 2026

Based on the proposed improvement strategies, a simulation was conducted to evaluate the improvement in the area's regenerative performance, resulting in the CEI improvement values shown in Table 7.

Table 7. Simulation of Indicator Improvements Toward Regenerative Targets

Indikator	Baseline Master Plan	Improvement Regenerative (%)	Strategy Description
Local Materials (ML)	43,04	55,52	Substitution of non- with local materials
Reuse Material (IRM)	1,90	20,06	Integration of reuse into design
Waste Circular Index (WCI)	80,00	80,00	Waste system remains optimal
Material Efficiency (ME)	52,08	61,58	Design and construction efficiency
CEI	44,25	54,29	Strong transition toward regenerative

Source: Author, 2026

Based on the simulation results in Table 7, regenerative performance at the masterplan stage can be improved through interventions across each circular economy indicator. Local

material use (ML) increased from 43.04% to 55.52% through the substitution of non-local materials, while material reuse (IRM) rose from 1.90% to 20.06% through the integration of reused materials into the area's design and construction. The Waste Circular Index (WCI) remained stable at 80.00%, indicating the importance of maintaining a consistent closed-loop waste management system. Material efficiency (ME) also improved from 52.08% to 61.58% through design and construction optimization. Overall, these strategies increased the total CEI value from 44.25% to 54.29%, reflecting a transition toward a more circular and regenerative system. This improvement demonstrates efforts to preserve material value through local resource optimization, reuse, efficiency, and waste reduction within an integrated system (Ellen MacArthur Foundation, 2015; Geissdoerfer et al., 2017), while also indicating a shift from linear to adaptive closed-loop material flows in line with urban metabolism principles (Kennedy et al., 2011).

5. CONCLUSION

The research results indicate that the Pancoh Ecotourism Village Master Plan is still in a transitional phase toward a circular and regenerative system, with a Circular Economy Index (CEI) value of 44.25%, while the existing conditions show a lower value of 17.08%. The master plan's score is influenced by the high use of local materials and the waste circular index, yet it remains low in terms of material reuse and material efficiency. From the Ellen MacArthur Foundation's circular economy perspective, this indicates that the area's material system has not yet fully formed a closed-loop cycle, resulting in material flows that remain predominantly linear. A comparison with the existing conditions reveals implementation gaps, particularly in waste management and the integration of the area's material system.

Improvement strategies are focused on optimizing local materials, integrating material reuse, enhancing construction efficiency, and strengthening closed-loop-based waste management systems. Simulations indicate that these strategies can increase the master plan's CEI score to 54.29%, signaling a shift toward a more circular and nearly regenerative regional system. This study remains limited to a circular economy approach, specifically regarding materials; therefore, future research is recommended to develop a regenerative agro-ecotourism approach that is more integrated ecologically, socially, and economically.

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