



Directions for Circular Economy Development in Thanh Hoa Province: Potential, Challenges, and Policy Implications

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ABSTRACT: A circular economy seeks to retain the value of products, materials, and resources within the economy while reducing waste generation and pressure on virgin-resource extraction. In Thanh Hoa Province, this transition is closely associated with the industrial concentration of Nghi Son Economic Zone, municipal solid waste management, agricultural value chains, and tourism. This article uses document analysis, policy analysis, and descriptive synthesis of secondary data published up to 25 October 2026. The findings indicate that Nghi Son offers a setting in which industrial symbiosis can be investigated, although investment scale and nameplate capacity do not demonstrate that material flows are already circular. In 2025, Thanh Hoa generated approximately 920,178.25 tonnes of municipal solid waste; the collection and treatment rate reached 93.68%, while landfilling remained substantial. The article recommends establishing a material-flow baseline, piloting industrial symbiosis, improving source separation, developing secondary-material markets, and adopting resource-efficiency indicators. Because the study relies on secondary data and does not audit material flows at individual firms, the proposed interventions require field validation.

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I. INTRODUCTION

The linear economic model based on resource extraction, production, consumption, and disposal is facing growing pressure from resource constraints, waste-management costs, and the requirements of low-emission development. A circular economy is not limited to post-consumer recycling; it also encompasses waste-preventive design, product-life extension, repair, reuse, remanufacturing, and the restoration of natural systems. This approach requires assessment across product life cycles and value chains rather than a narrow focus on end-of-pipe treatment (United Nations Economic Commission for Europe [UNECE], 2024). In Vietnam, the Circular Economy Development Scheme was approved under Decision No. 687/QĐ-TTg of 7 June 2022, establishing a national policy direction for the transition (Prime Minister of Vietnam, 2022).

The legal framework for the circular economy and waste management is set out in the Law on Environmental Protection No. 72/2020/QH14, Decree No. 08/2022/ND-CP, and amendments issued during 2025–2026. In relation to extended producer responsibility, Decree No. 110/2026/ND-CP specifies producers' and importers' responsibilities for product and packaging recycling and waste treatment, providing a basis for linking corporate obligations with material-recovery outcomes (National Assembly of Vietnam, 2020; Government of Vietnam, 2022, 2025, 2026a, 2026b).

Thanh Hoa has a diversified production structure encompassing oil refining and petrochemicals, cement, metallurgy, agriculture, tourism, and logistics. Under the master plan adjusted and expanded in 2018, Nghi Son Economic Zone covers 106,000 hectares, including 66,497.57 hectares of land and islands and 39,502.43 hectares of water surface (Prime Minister of Vietnam, 2018). A 2023 report noted that the economic zone accommodated 25 industrial parks covering more than 9,000 hectares (VnEconomy, 2023). This concentration creates an opportunity to investigate material exchanges between production facilities, but it does not, in itself, demonstrate that industrial symbiosis or resource reuse has been implemented effectively.

Empirical research in Vietnam has begun to examine the conditions under which firms adopt circular business models. A survey of 291 firms found that financial factors—including access to capital, expected economic benefits, and cost-management competence—had a stronger influence on intentions to adopt circular business models than non-financial factors (Tran & Nguyen-Thi-Phuong, 2024). A study evaluating 35 industrial parks in Vietnam demonstrated how eco-efficiency can be assessed by combining input-output indicators with multi-criteria evaluation rather than relying on investment scale alone (Nguyen et al., 2025). A regional assessment published in 2026 found uneven circularity readiness across Vietnam's ecological-economic regions; under the study's framework, the North Central Coast and Central Coast region was assessed as having medium readiness (Bui et al., 2026).

Research on scaling up circular-economy models in Vietnam further suggests that economic, social, and environmental benefits often remain concentrated in individual initiatives, while expansion is constrained by policy gaps, financial risks, and infrastructure limitations (Bui & Pham, 2026). A study published on 22 October 2026, using 2025 survey data from 1,600 cases across eight provinces and cities, found that industrial actor linkages were strongest in waste collection and treatment and weaker in technology exchange, technical knowledge sharing, and workforce training (Nguyen et al., 2026). These findings suggest that circular-economy development in Thanh Hoa must combine physical infrastructure with coordination mechanisms, shared data, and economic incentives. Accordingly, this article clarifies the circular-economy approach at the provincial level, analyses opportunities and gaps using traceable secondary data, and proposes policy directions that can be tested empirically.

II. THEORETICAL BACKGROUND AND RESEARCH METHODS

2.1. Theoretical background

In this study, a circular economy is understood as a way of organising production and consumption to reduce the use of virgin resources, retain the value of products and materials for as long as possible, and minimise waste requiring disposal. A measurement framework should therefore track not only recycling volumes but also material use, product design, consumption, innovation, competitiveness, and supply-chain sustainability. UNECE's measurement guidelines emphasise the need for consistent concepts and indicators to support comparisons across jurisdictions (UNECE, 2024). The European Commission's revised monitoring framework adds dimensions related to competitiveness, innovation, and economic resilience (European Commission, 2023). A 2025 report on indicators for the circular transition also recommends greater attention to higher-value circular activities and indicators tailored to specific material flows, sectors, and policy priorities (European Commission et al., 2025).

At the local level, circularity can be examined through four main flows: materials, energy, water, and post-consumer products. For industry, the focus is on material efficiency, by-product exchange, waste-heat recovery, and water reuse. For agriculture, it is on biomass recovery, by-product utilisation, and livestock-waste treatment. For urban areas and tourism, priorities include reducing single-use products, separating waste at source, and recovering packaging. These flows can be connected only when information is available on volume, quality, timing, transport costs, and potential demand. The Vietnamese industrial-park eco-efficiency study, which combined data envelopment analysis with the Analytic Hierarchy Process, offers a methodological reference for designing sector-sensitive indicators for industrial areas in Thanh Hoa (Nguyen et al., 2025).

The circular economy is also a matter of governance, investment, and inter-organisational coordination. The 2026 readiness framework developed for data-scarce contexts includes five dimensions: policy, resource management, innovation, business ecosystem, and awareness (Bui et al., 2026). This framework is relevant to Thanh Hoa because available figures often describe production capacity or waste generation, whereas data on secondary materials, exchanged by-products, and reused water remain limited. Research on Vietnamese businesses likewise identifies finance, expected economic benefits, and cost-management competence as important drivers of circular-business-model adoption (Tran & Nguyen-Thi-Phuong, 2024). Technical interventions therefore need to be accompanied by financing mechanisms, quality standards, contractual arrangements, and stable markets for recovered outputs.

2.2. Research methods

The article uses document analysis, policy analysis, and descriptive synthesis of secondary data. The dataset was closed on 25 October 2026 and comprises national legislation and policy documents; publications by public agencies, news organisations, and firms; municipal solid waste data for Thanh Hoa; and academic studies published during 2023–2026 on circular-economy measurement, circular business models, industrial-park eco-efficiency, and industrial symbiosis. Academic sources were selected according to their direct relevance to the research questions, methodological transparency, and retrievability.

The analysis proceeded in three steps. First, the conceptual framework, measurement tools, and institutional conditions for a circular economy were identified. Second, this framework was compared with the characteristics of industry, agriculture, urban services, tourism, and logistics in Thanh Hoa. Third, traceable quantitative information was synthesised, consistency among indicators was checked, and data gaps were identified. The study did not conduct primary surveys, material-flow audits, or physical waste-composition measurements. Accordingly, industrial-symbiosis and material-recovery models are proposed interventions rather than empirically verified outcomes in Thanh Hoa. The milestones in the proposed roadmap are analytical recommendations, not official provincial targets.

III. RESEARCH FINDINGS

3.1. Development scale and the need to transform the growth model

Thanh Hoa's diversified economy provides a basis for examining cross-sector circular models. Large-scale industry creates demand for materials, energy, and water; agriculture generates biomass and by-product streams; urban areas and tourism produce concentrated waste flows; and ports and transport networks may support the movement of recovered materials. However, the co-existence of material flows within one geographical area does not automatically create a circular system. Before an intervention is designed, the volume, characteristics, timing, transport cost, safety requirements, and commercial outlets for each flow must be established.

A report published on 8 October 2026, summarising performance through the first nine months of the year, estimated Thanh Hoa's gross regional domestic product (GRDP) growth at 8.54%, ranking the province 22nd among 34 provinces and centrally governed cities (Communist Party of Vietnam, 2026). This is an indicator of the growth context, not a direct measure of circularity. Alongside conventional growth indicators, the province should track material productivity, energy intensity, water reuse, waste diverted from landfill, and the quantity of recovered materials returned to production.

Table 1. Selected baseline indicators relevant to circular-economy development in Thanh Hoa Province

Indicator	Reported value	Implication for the circular economy
GRDP growth in the first nine months of 2026	Estimated at 8.54%	Resource efficiency should be measured alongside economic growth.
Planned area of Nghi Son Economic Zone	106,000 ha: 66,497.57 ha of land and islands and 39,502.43 ha of water surface	Provides a spatial basis for mapping material, energy, and water flows.
Industrial areas in Nghi Son Economic Zone	25 industrial parks covering more than 9,000 ha	A basis for identifying business clusters and priority material flows.
Nghi Son Refinery and Petrochemical LLC	Investment exceeding USD 9 billion; design capacity of 200,000 barrels per day, equivalent to about 10 million tonnes per year	Priority for auditing energy, water, by-products, and industrial material flows.
Nghi Son Cement	Combined capacity of two production lines: about 4.3 million tonnes per year	Capacity should not be treated as a measure of actual output, resource consumption, or waste.

Source: Communist Party of Vietnam (2026); Prime Minister of Vietnam (2018); VnEconomy (2023); Nghi Son Refinery and Petrochemical LLC (2026); Ximang.vn (2025). Figures for industrial facilities refer to announced or design capacity, not actual annual output.

3.2. Nghi Son Economic Zone and the potential for industrial symbiosis

Nghi Son Economic Zone is a priority setting in which to investigate industrial symbiosis because it hosts a concentration of industries that consume substantial quantities of materials, energy, and water. Nghi Son Refinery and Petrochemical LLC reports total investment exceeding USD 9 billion and a design processing capacity of 200,000 barrels of crude oil per day, equivalent to approximately 10 million tonnes annually (Nghi Son Refinery and Petrochemical LLC, 2026). Nghi Son Cement operates two production lines with a combined capacity of about 4.3 million tonnes per year (Ximang.vn, 2025). These are announced or design-capacity figures; they are not measures of actual production, resource consumption, or recoverable by-products. Circularity potential must therefore be established through facility-level audits of material, energy, and water flows.

Industrial symbiosis is a form of coordination in which one facility's by-products, surplus heat, treated water, or recovered materials can become another facility's inputs, provided they satisfy technical standards, environmental requirements, and economic conditions. Evidence from Vietnam indicates that industrial symbiosis cannot be inferred from geographic proximity alone: links for waste collection and treatment tend to be easier to establish than links involving technology transfer and capability development (Nguyen et al., 2026). The first step in Nghi Son should therefore be to map material and energy flows within each industrial sub-zone, documenting raw-material inputs, water use, wastewater quality, surplus heat, by-products, industrial waste, and potential input needs among neighbouring firms.

Material exchange should be considered effective circularity only when three conditions are met: technical and environmental compliance; economic viability relative to the existing alternative; and clear allocation of responsibilities among the generator, receiver, and transporter. Without quality standards, traceability, and reliable contracts, transferring by-products between firms may shift environmental risks rather than reduce them. The province's role should focus on data coordination, pilot support, stakeholder matching, and regulatory enforcement, without substituting for firms' own compliance responsibilities.

3.3. Municipal solid waste and the gap in value recovery

Under Thanh Hoa's 2026–2030 scheme for household solid waste collection, transportation, and treatment, the province generated an estimated 920,178.25 tonnes of municipal solid waste in 2025, equivalent to 2,521.04 tonnes per day (Thanh Hoa Provincial People's Committee, 2026). A report by Thanh Hoa Newspaper, citing the provincial Department of Agriculture and Environment, states that average waste generation in urban areas is about 1.2 kilograms per person per day, compared with approximately 0.5–0.8 kilograms in rural areas (Thanh Hoa Newspaper, 2026b). These volumes require integrated management of waste prevention, separation, collection, transport, and material recovery rather than an approach centred solely on expanding end-of-pipe treatment capacity.

The province-wide collection and treatment rate for municipal solid waste was 93.68% in 2025, with approximately 2,361 tonnes collected, transported, and treated each day (Thanh Hoa Provincial People's Committee, 2026; Thanh Hoa Newspaper, 2026b). The provincial scheme estimates that about 1,170.86 tonnes per day were landfilled, equivalent to 49.58% of the treated volume. Landfill dependence was higher in some localities, at approximately 74.7% in Hac Thanh Ward and more than 85% in Sam Son Ward and Nam Sam Son Ward (Thanh Hoa Provincial People's Committee, 2026). Local rates should not be substituted for the province-wide figure because their statistical coverage differs. Although the collection rate is relatively high, recyclable or reusable materials may still be lost when waste is not separated and is ultimately sent to landfill.

This review did not identify a representative waste-composition survey covering all areas of Thanh Hoa. A generic organic-waste share should therefore not be used to estimate province-wide recovery potential. To choose among composting, organic fertiliser production, material recovery, and other technologies, the province needs sampling across urban, rural, and mountainous areas, seasons, and waste sources. Measurements should include moisture, contamination, output quality, transport costs, and market demand. Source separation is a foundational condition for reducing material contamination and improving the economic performance of recovery options.

Table 2. Selected indicators for municipal solid waste in Thanh Hoa Province

Indicator	Value	Policy significance
Total municipal solid waste generated in 2025	920,178.25 tonnes per year	A material-specific and geographically disaggregated data system is needed.
Average daily waste generation	2,521.04 tonnes per day	Creates significant pressure on collection, treatment, and land availability.
Province-wide collection and treatment rate in 2025	93.68%; about 2,361 tonnes collected, transported, and treated per day	Monitoring should move beyond collection rates to material-recovery outcomes.
Waste treated through landfilling across the province	About 1,170.86 tonnes per day, or 49.58% of the treated volume	There remains scope to reduce landfilling and recover resources.
Landfill share in selected localities	Hac Thanh Ward: 74.7%; Sam Son Ward and Nam Sam Son Ward: over 85%	Locality-level conditions should be analysed separately and not generalised province-wide.
Average waste generation by area	Urban: about 1.2 kg/person/day; rural: about 0.5–0.8 kg/person/day	Separation and collection systems should reflect local waste-generation patterns.
Waste separated and treated at source	About 461 tonnes per day, according to data reported in 2026	The composition, quality, and destination of recovered materials should be verified.
Waste collected, transported, and treated centrally	About 1,900 tonnes per day, according to data reported in 2026	Collection schedules should be coordinated with transport and treatment capacity.

Source: Thanh Hoa Provincial People's Committee (2026) and Thanh Hoa Newspaper (2026a, 2026b). Locality-specific rates are reported separately; landfill rates for individual wards are not extrapolated to the entire province.

3.4. Agriculture, tourism, and reverse logistics in a circular system

Agriculture can support biomass-based material cycles. Crop residues may be collected for use as organic inputs, animal feed, or processing feedstock; livestock waste may be treated to produce organic fertiliser or biogas when technical and environmental requirements are satisfied. These models often face dispersed feedstocks, seasonal variation, collection costs, and an absence of stable outlets. Studies of circular-economy models in Vietnam indicate that agricultural initiatives can generate economic, social,

and environmental benefits, but scaling them up is difficult without suitable infrastructure, coordination mechanisms, and financing (Bui & Pham, 2026). Cooperatives, processors, transport providers, and end users should therefore be organised around specific product chains.

In tourism, a circular approach can begin with reducing single-use plastics, separating packaging, managing food waste, and recovering materials at accommodation providers, restaurants, attractions, and events. Research on tourism development and marine cultural heritage conservation in Thanh Hoa does not directly measure waste flows, but it provides contextual evidence for linking tourism with conservation and sustainable development (Hung & Tuyen, 2026). Circular interventions at destinations should thus be integrated into destination management, service-operation standards, and community participation rather than limited to environmental communication.

Reverse logistics connects post-use products, packaging, and recovered materials with sorting, recycling, or reuse facilities. Transport infrastructure and port facilities at Nghi Son provide a basis for exploring links among industrial zones, urban areas, and production regions, although actual performance depends on supply consistency, material quality, transport distance, and long-term contracts. The province can facilitate this process through a database of secondary-material supply, demand, location, and quality standards. Firms can disclose information on the type and volume of potentially exchangeable by-products, subject to commercial confidentiality and environmental law (UNECE, 2024).

3.5. Data gaps and implementation capacity

A major gap is that available data mainly describe investment scale, production capacity, or waste generation, whereas core circular-economy indicators are not reported consistently. Within the sources reviewed, there is insufficient information to determine the share of secondary raw materials in industrial inputs, the volume of water reused in industrial parks, the quantity of by-products exchanged between firms, or recycling rates by material category across the province. This gap aligns with recent measurement and readiness frameworks, which emphasise consistent indicators while allowing methods to accommodate data-scarce settings (UNECE, 2024). Vietnam's regional readiness assessment likewise identifies differences across regions and recommends strengthening monitoring systems (Bui et al., 2026). Large industrial scale should therefore not be interpreted as evidence of high circularity.

Implementation capacity depends on coordination among public authorities, firms, collection and recycling operators, research institutions, cooperatives, and communities. Evidence from 1,600 cases across eight provinces and cities suggests that existing linkages remain concentrated in waste collection and treatment, while technology sharing, technical knowledge exchange, and workforce development are weaker (Nguyen et al., 2026). Firm-level research in Vietnam also identifies finance and expected economic benefits as important conditions for adopting circular business models (Tran & Nguyen-Thi-Phuong, 2024). Thanh Hoa must therefore develop technical capacity, coordination arrangements, and mechanisms for sharing costs and benefits. Research on financial-reporting transparency and investment attraction in the province's startup ecosystem does not measure circularity directly, but offers contextual insight into the importance of information transparency in investment governance (Le & Tran, 2025).

IV. DISCUSSION

The analysis reveals both opportunities and transition pressures for Thanh Hoa. The industrial concentration at Nghi Son creates scope for investigating industrial symbiosis, while the large volume of municipal solid waste requires reduced dependence on landfilling. Agriculture can contribute biological cycles, and tourism and logistics create material streams that need to be recovered. However, scale advantages translate into circular outcomes only when material flows are measured, meet applicable standards, and are connected to real demand. Research on the scaling of circular-economy models in Vietnam emphasises that individual initiatives may produce local benefits yet remain difficult to expand without institutional, financial, and infrastructural connections (Bui & Pham, 2026).

First, policy should move from separate sector-based management towards material-flow management. Agencies responsible for industry, the environment, agriculture, construction, tourism, and logistics need compatible datasets to identify where materials arise, what can be recovered, and where demand exists. When sectors maintain disconnected data systems, opportunities for cross-sector exchanges are harder to identify. This approach is consistent with the European Commission's multi-dimensional circular-economy monitoring framework (European Commission, 2023). The 2025 indicator report also recommends monitoring higher-value circular activities and indicators tailored to specific material flows (European Commission et al., 2025).

Second, waste treatment should be distinguished from circular outcomes. A treatment facility may reduce the harmful effects of waste without producing secondary materials of sufficient quality or market value. Performance indicators should therefore include the quantity of materials returned to production, the proportion of waste diverted from landfill, water reused, and the economic performance of recovery cycles. Decree No. 110/2026/ND-CP, which governs producer and importer responsibilities for product and packaging recycling and waste treatment, provides an additional basis for linking corporate obligations with material-recovery outcomes (Government of Vietnam, 2026b). Output-based indicators would reduce the risk of assessing performance solely by the number of projects or nominal treatment capacity.

Third, circular-economy principles should be incorporated into investment promotion without imposing identical criteria on every sector. Oil refining, cement, and metallurgy projects should be assessed on energy intensity, water efficiency, by-product management, and waste-heat recovery. Tourism projects should prioritise waste prevention, water saving, and packaging recovery, while agriculture should focus on biomass, livestock waste, and reliable outlets for organic products. Input, output, and environmental-cost disclosure should be standardised. The Vietnamese industrial-park eco-efficiency study provides a reference for developing criteria that reflect sectoral characteristics and operating conditions (Nguyen et al., 2025). The Thanh Hoa study of financial transparency and investment attraction is used here as contextual evidence on information governance, not as direct evidence of circular-economy performance (Le & Tran, 2025).

Fourth, the roadmap should begin with measurable pilots rather than aggregate targets unsupported by a baseline. Nghi Son could be selected for industrial-symbiosis audits; selected urban areas or tourist destinations could pilot source separation and packaging recovery; and selected agricultural chains could trial residue collection. Before scaling up, the province should publish the quantities of recovered materials, costs, revenues, waste diverted from landfill, and environmental outcomes. Decision No. 46/2026/QĐ-TTg, which provides guidance on identifying green projects, projects meeting circularity criteria, and the application of environmental, social, and governance standards, was issued on 17 September 2026 and is scheduled to take effect on 1 November 2026. Provincial criteria should be reviewed for consistency with the decision when it becomes effective (Prime Minister of Vietnam, 2026).

This study has several limitations. First, it relies on secondary data and includes no direct survey of firms, waste-treatment facilities, or farming households. Second, some figures refer to specific localities or design capacity and cannot be treated as actual production data or generalised to the entire province. Third, no unified dataset was found for secondary-material volumes, by-product exchanges, reused water, or recycling rates by material category. Future research should add material-flow audits in industrial parks, cost-benefit analysis, and surveys of firms' willingness to participate in order to test the feasibility of the proposed measures.

V. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The circular economy can become an important direction for transforming Thanh Hoa's growth model, but progress depends on converting material streams currently treated as waste into safe, valuable inputs for new production cycles. Nghi Son Economic Zone should be prioritised for industrial-symbiosis assessment. Municipal solid waste management needs to shift from an emphasis on collection and landfill towards prevention, separation, and recovery. Agriculture, tourism, and logistics can contribute additional circular loops when organised around value chains and supported by viable markets.

5.2. Policy and practical recommendations

Based on the analysis, five policy priorities are proposed. First, the province should develop a circular-economy programme that identifies a coordinating agency, priority sectors, resources, indicators, and reporting arrangements. Second, material, energy, and water audits should be conducted at selected industrial sites in Nghi Son, followed by the identification of firm pairs that could exchange by-products or reuse water. Third, waste prevention and source separation should be prioritised, waste-composition data improved, and markets for recovered materials developed. Fourth, circular agriculture and low-waste tourism models should be developed around selected product chains or destinations with business and community participation. Fifth, a monitoring framework should distinguish input, output, and impact indicators; quantitative targets should be adopted only after a baseline, measurement method, and verification process have been established.

Table 3. Proposed roadmap for circular-economy development in Thanh Hoa Province

Period	Implementation focus	Indicators to monitor
2026–2030	Establish a data baseline; audit material flows at selected facilities in Nghi Son; pilot source separation in selected localities.	Number of facilities with material-flow audits; volume of materials recovered; source-separation rate; waste diverted from landfill.
2031–2035	Scale up evaluated models; build a supply-and-demand network for secondary materials; connect agricultural and tourism value chains.	Share of secondary inputs in participating facilities; amount of water reused; revenue from recovered materials; avoided costs.
2036–2050	Integrate circular principles into planning, investment selection, and supply-chain management more broadly.	Material and energy intensity; share of waste diverted from landfill; emissions per unit of value added.

Source: Author's proposal based on UNECE (2024) and the European Commission (2023, 2025). The indicators are suggestions for establishing a baseline and official targets; they are not targets formally adopted by the provincial government.

The roadmap should be operationalised through a verifiable baseline and targets appropriate to each sector. The province should avoid quantitative targets before the measurement method, statistical scope, and verification arrangements are clear. A data-driven approach can position the circular economy as a programme for improving resource productivity and competitiveness rather than as an environmental aspiration expressed only in general terms.

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