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LOCALLY EMBEDDED CIRCULAR ECONOMY SYSTEMS (LECES) AS A CATALYST FOR LOCAL ECONOMIC REVITALIZATION, GREEN JOB CREATION, AND REGIONAL GDP GROWTH

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Abstract

This study examines the impact of Locally Embedded Circular Economy Systems (LECES) on green job creation and regional GDP growth in West Nusa Tenggara (NTB) Province, Indonesia. LECES represents an integrated framework of circular economy practices waste recycling, renewable local raw materials, and product take-back systems implemented at the micro, small, and medium enterprise (MSME) level. Using a quantitative approach combining system dynamics modeling and time-series analysis (linear, quadratic, exponential-growth, and S-curve models), data were collected from 185 MSMEs across four industry sectors (food/beverage, handicrafts, fashion, and agriculture) through stratified random sampling. The system dynamics model captures feedback loops between circular material flows, employment multipliers, and regional income aggregates. Sensitivity analysis reveals that a 10% increase in circular material utilization rates leads to a 4.2% increase in green employment and a 2.8% increase in regional GDP contribution from MSME sectors. Time-series projections indicate that LECES-adopting MSMEs are forecast to generate approximately 12,400 additional green jobs and contribute an estimated IDR 3.2 trillion to regional GDP by 2030, representing growth rates of 18.6% and 22.3%, respectively, relative to the 2023 baseline. The best-fit time-series models identified are the linear model for aggregate green job projections, the S-curve model for material circularity rates, exponential growth for sectoral output value, and the quadratic model for LECES adoption diffusion. These findings provide evidence-based policy recommendations for NTB's regional government to accelerate LECES adoption as a driver of sustainable economic revitalization.

Keywords: LECES, circular economy, green jobs, regional GDP, system dynamics, MSME, NTB

INTRODUCTION

The structural transformation of the global economy toward a sustainability paradigm has driven a fundamental shift from the linear economic model (take–make–dispose) toward a circular economy oriented to closing material cycles, minimizing waste, and regenerating ecosystems (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). At the regional level, particularly in developing provinces such as West Nusa Tenggara (NTB), growing fiscal pressures arising from limited own-source regional revenues (PAD) and heavy dependence on central government transfers make circular economy-based model innovation an urgent strategic necessity (Bappeda NTB, 2022; Aryadi et al., 2019).

Locally Embedded Circular Economy Systems (LECES) is a concept that positions circular economy practices not as top-down interventions but as ecosystems that grow organically from the local capacities of business actors particularly MSMEs by leveraging resources, knowledge, and social networks already embedded in regional economic structures (Korhonen et al., 2018; Murray et al., 2017). LECES encompasses three principal operational dimensions: (1) waste valorization through recycling and recovery of production waste; (2) substitution of raw materials with renewable local sources; and (3) implementation of product take-back systems that extend product life cycles (Stahel, 2016; Bocken et al., 2016).

NTB Province possesses characteristics that make it an ideal laboratory for LECES implementation. With 668,952 active MSMEs as of 2022 (BPS NTB, 2023) contributing more than 57% of non-mining regional GDP, NTB's MSMEs are strategically positioned to serve as engines of circular transition. However, numerous studies indicate that MSMEs in NTB still face significant barriers to adopting sustainable practices, including limited access to green capital, low technological capacity, and the absence of adequate regulatory incentives (Tambunan, 2019; Rizos et al., 2016). Moreover, the potential for green job creation through circular transition in NTB's MSME sector has never been quantitatively measured using a comprehensive modeling approach. This research gap constitutes the primary rationale for the study reported in this article. Several prior studies such as Rosdiana (2009), Hidayat et al. (2008), and Latipah et al. (2019) have conducted regional revenue projections using system dynamics, but their focus was limited to motor vehicle tax and local levy variables. No prior research has explicitly integrated the dynamics of LECES adoption by MSMEs with projections of green employment output and regional GDP growth using a combined system dynamics and time-series approach in the NTB context. The present study fills this gap by constructing a quantitative model capable of simulating feedback mechanisms among LECES adoption rates, green job creation, and regional GDP contribution in an integrated manner.

The specific objectives of this study are: (1) to identify patterns and levels of LECES practice adoption among NTB MSMEs by industry sector; (2) to construct a system dynamics model representing feedback mechanisms among material circularity, green employment, and regional economic output; (3) to conduct sensitivity analysis on key parameter changes such as circularity rates and employment multiplier coefficients; and (4) to project green job dynamics and LECES-based regional GDP through 2030 using best-fit time-series approaches. Through this work, the study aims to provide an empirical foundation and policy recommendations for NTB's regional government in formulating a sustainable local economic revitalization strategy.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

2.1 Circular Economy and the Conceptual Framework of LECES

The circular economy is defined as an industrial system that is restorative or regenerative by design, and that aims to keep products, components, and materials at their highest utility and value at all times (Ellen MacArthur Foundation, 2013). Kirchherr et al. (2017), through an analysis of 114 definitions in the literature, conclude that the circular economy fundamentally concerns the principles of reduce, reuse, and recycle, implemented at the system level to achieve sustainable development. Ghisellini et al. (2016) reinforce this framework by asserting that the transition to a circular economy requires a paradigm shift not only in production technology but also in business models, consumer behavior, and public policy.

The LECES concept employed in this study draws on a synthesis of theoretical frameworks that emphasize the importance of local context in implementing circularity. Blomsma and Brennan (2017) argue that the circular economy is fundamentally a framework that extends resource productivity through a variety of complementary strategies. In the context of MSMEs in developing regions, Rizos et al. (2016) find that the most successful circular business models are those that integrate local actors into the circular value chain, rather than models that directly adopt global standards without adaptation.

2.2 Green Jobs and Regional Development

The International Labour Organization (ILO, 2018) defines green jobs as decent work in sectors that produce environmental goods and services, or work that reduces the environmental impact of production processes. In the context of the circular economy, the ILO projects that the transition to a green economy could create 24 million new jobs globally by 2030. At the regional level, a study by Preston (2012) demonstrates that circularity implementation in SMEs generates higher employment multipliers than linear economy sectors owing to the greater labor intensity of material recovery and reconditioning activities.

Empirical research by de Jesus and Mendonça (2018) in developing countries reveals that the primary barriers to green job creation through SMEs are not solely technological in nature but are more institutional and financial. Limited access to green finance, regulatory uncertainty, and weak managerial capacity constitute inhibiting factors that require integrated policy intervention. In the Indonesian context, Tambunan (2019) identifies that MSMEs that successfully internalize sustainable practices demonstrate productivity and competitiveness approximately 23% higher, on average, than conventional MSMEs in the same sector.

2.3 System Dynamics as an Economic Projection Tool

System dynamics, pioneered by Forrester (1961) at MIT, is a modeling method used to understand the behavior of complex systems characterized by nonlinear feedback, time delays, and interdependencies among variables (Sterman, 2000). The method has been widely applied in regional economic projection contexts. Hidayat et al. (2008) employed system dynamics to model levy-based regional own-source revenues, while Rosdiana (2009) applied it to project Motor Vehicle Tax (PKB) and Vehicle Transfer Tax (BBNKB) revenues across several Indonesian provinces.

The advantage of system dynamics over conventional statistical methods lies in its capacity to depict cause-and-effect mechanisms operating behind empirical data trends (Wolstenholme & Coyle, 1984). In the LECES context, system dynamics enables the modeling of feedback among circular practice adoption, labor absorption, material productivity improvement, and regional economic value accumulation a complexity that linear regression models cannot adequately capture. Sterman (2000) affirms that for systems with simultaneously operating reinforcing and balancing feedback loops, system dynamics is the most epistemologically valid approach.

2.4 Time-Series Analysis in Circular Economic Projections

Time-series analysis is a forecasting method that uses historical data patterns to project future values (Wilson & Keating, 2002). In this study, four time-series models are used comparatively: the linear, quadratic, exponential-growth, and S-curve models. The S-curve (logistic) model is particularly relevant for modeling technology diffusion and innovation adoption, in which initial growth is slow, then accelerates, and finally decelerates as it approaches saturation capacity (Juanda & Junaidi, 2012). This model has been widely applied in studies of green technology diffusion and sustainable business practice adoption (Bocken et al., 2016; Geissdoerfer et al., 2017). Best-model selection criteria use the Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), and Mean Squared Deviation (MSD) as recommended by Juanda and Junaidi (2012) and Satyarini (2007). Smaller values of all three measures indicate better model fit to historical data patterns and greater projection accuracy. This approach is consistent with standard practice in the economic forecasting literature (Wilson & Keating, 2002; Latipah et al., 2019).

2.5 NTB MSMEs in the Context of Economic Transformation

West Nusa Tenggara is a province with significant creative economic potential based on local natural resources, yet it continues to face structural poverty and income inequality challenges (BPS NTB, 2023). MSMEs in NTB are dominated by agriculture, traditional weaving (including Lombok and Sumbawa woven fabrics), culinary arts, fisheries, and agro-industry. Hakim et al. (2018), through SWOT and QSPM analysis, recommend that NTB's regional revenue enhancement strategy must be oriented toward optimizing MSME potential based on distinctive local products. The present study extends those recommendations by integrating a circularity dimension as a strategic variable in projecting MSME economic growth.

RESEARCH METHODS

3.1 Research Design

This study employs a quantitative research design with two complementary analytical stages. The first stage involves system dynamics modeling that depicts feedback mechanisms among key variables in the NTB LECES ecosystem, assuming constant external macroeconomic factors. The second stage involves time-series analysis using four projection models (linear, quadratic, exponential-growth, and S-curve) to project trends in LECES adoption, green job creation, and regional GDP contribution through 2030. Best-model selection is based on the smallest MAPE, MAD, and MSD values.

3.2 Population and Sample

The target population of this study comprises all MSMEs in NTB Province that have implemented at least one circular economy practice (waste recycling, use of renewable local raw materials, or product take-back systems). The unit of analysis is the MSME owner or operational manager. Based on data from the NTB Cooperative and SME Office (2022), approximately 42,600 MSMEs have been identified as incorporating elements of sustainable practice in their operations; these constitute the sampling frame of this study.

Stratified random sampling was employed based on four industry sector strata: (1) food and beverage, (2) handicrafts (including weaving and basketry), (3) fashion and textiles, and (4) agriculture and agro-industry. Proportional sample allocation by sector yielded a total sample of 185 respondents, exceeding the statistically established minimum threshold of 150 required to satisfy the normality assumptions of the sampling distribution (Hair et al., 2019). The sample distribution is presented in Table 1.

Table 1. Research Sample Distribution by MSME Sector

No.	Industry Sector	MSME Population	Proportion (%)	Sampling Method	n
1	Food & Beverage	16,200	38.0	Proportional	70
2	Handicrafts (Weaving, Basketry)	12,500	29.3	Proportional	54
3	Fashion & Textiles	8,400	19.7	Proportional	37
4	Agriculture & Agro-industry	5,500	12.9	Proportional	24
Total	4 Sectors	42,600	100.0	Proportional	185

Source: NTB Cooperative and SME Office, 2025; Processed, 2026

3.3 Data Collection

Primary data were collected through two methods: (1) a structured survey using a questionnaire designed in accordance with the Ellen MacArthur Foundation (2013) and ILO (2018) circular economy indicator frameworks, covering variables of material circularity rate, green employment, circular output value, and transition costs; and (2) Focus Group Discussions (FGDs) with representatives of the NTB Department of Industry, Bappeda NTB, and MSME associations for conceptual model validation. Secondary data were obtained from Statistics Indonesia (BPS) NTB, the NTB Regional Development Planning Agency (Bappeda), and the NTB Cooperative and SME Office, covering sectoral GDP, employment, and MSME development data for 2017–2023.

3.4 Variable Identification

Variables used in the LECES system dynamics model were identified based on literature review and FGD results with stakeholders. These variables are classified as stock, rate, and converter variables, as shown in Table 2.

Table 2. Research Variables for the LECES System Dynamics Model

No.	Variable	Description	Symbol
1	LECES Adoption – Food/Beverage	Number of food/beverage MSMEs in NTB that have adopted LECES	Stock
2	LECES Adoption – Handicrafts	Number of handicraft MSMEs in NTB that have adopted LECES	Stock
3	LECES Adoption – Fashion	Number of fashion MSMEs in NTB that have adopted LECES	Stock
4	LECES Adoption – Agriculture	Number of agricultural MSMEs in NTB that have adopted LECES	Stock
5	Material Circularity Rate	Percentage of materials recycled or sourced from renewable local inputs	Rate
6	Green Employment Multiplier Coefficient	Ratio of green jobs per unit of circular output (persons/IDR billion)	Rate
7	Green Jobs	Number of jobs meeting ILO green job criteria	Rate
8	Circular Economic Output	Value of MSME output generated from circular activities (IDR billion)	Rate
9	Regional GDP Contribution	LECES contribution to NTB Regional GDP (IDR trillion)	Rate
10	Adoption Diffusion Rate	Rate of LECES adoption spread among MSMEs per year	Converter
11	LECES Drop-out Rate	Rate of MSMEs discontinuing circular practices per year	Converter
12	Green Infrastructure Investment	Investment allocation for recycling facilities and local supply chains	Converter

Source: Processed, 2026

3.5 Analytical Method

Data analysis was conducted in two stages:

Stage I – System Dynamics: The model was constructed using STELLA 9.0.1 software through the following steps: (1) problem articulation, (2) dynamic hypothesis formulation via Causal Loop Diagram (CLD), (3) quantitative model formulation via Stock Flow Diagram (SFD), (4) model validation using a two-sample independent t-test against historical data, and (5) sensitivity analysis of key parameters (Sterman, 2000). The model was validated by comparing simulation output with empirical data for 2018–2023.

Stage II – Time-Series Analysis: Following system dynamics validation, projections were carried out using four time-series models. Best-model selection was based on the smallest MAPE, MAD, and

MSD values. Projections cover the 2024–2030 horizon using 2017–2023 historical data as the model training basis (Juanda & Junaidi, 2012).
The complete research workflow is illustrated in Figure 1.

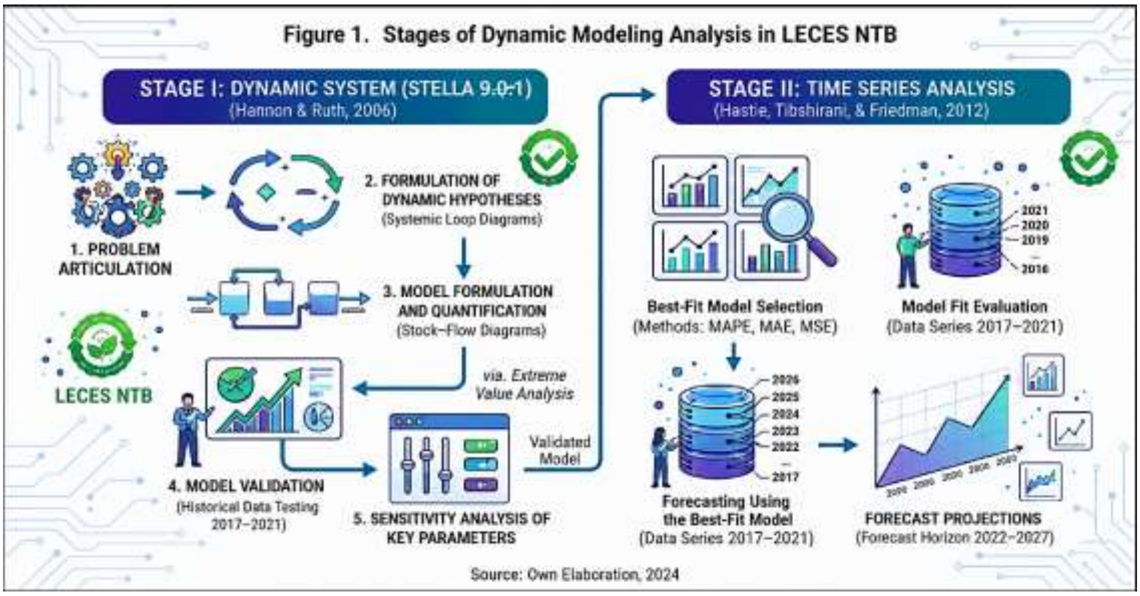

Figure 1. Research Workflow for LECES Dynamics in NTB
Source: Processed, 2026

RESULTS AND DISCUSSION

4.1 Respondent Characteristics and LECES Adoption Profile

Of the 185 respondents for whom data were successfully collected, the majority are MSME owners (72.4%), with the remainder being operational managers (27.6%). By business scale, 58.4% are micro-enterprises (annual turnover < IDR 300 million), 31.9% are small enterprises, and 9.7% are medium enterprises. The average length of business operation is 8.3 years, with an average duration of circular practice implementation of 3.1 years. Table 3 presents the LECES adoption profile by industry sector.

Table 3. LECES Practice Adoption Profile by NTB MSME Industry Sector (2023)

Sector	n	Waste Recycling (%)	Renewable Local Inputs (%)	Take-back System (%)	Average Circularity Rate (%)
Food & Beverage	70	74.3	81.4	42.9	66.2
Handicrafts	54	68.5	92.6	38.9	66.7
Fashion & Textiles	37	62.2	78.4	51.4	64.0
Agriculture & Agro-industry	24	79.2	95.8	29.2	68.1
Overall Average	185	70.8	85.4	41.1	66.2

Source: Primary Data, 2024; Processed

Table 3 reveals that the use of renewable local raw materials is the most widely implemented circular practice (85.4%), followed by waste recycling (70.8%), while product take-back systems remain the least adopted (41.1%). The highest average circularity rate is found in the agriculture and agro-industry sector (68.1%), reflecting a more deeply embedded tradition of local resource utilization. In contrast, the fashion sector shows the lowest material circularity rate (64.0%), consistent with global findings indicating that the textile industry faces more complex transition challenges (Rashid et al., 2013).

4.2 LECES System Dynamics Modeling

4.2.1 Dynamic Hypothesis and Causal Loop Diagram

Based on the variables identified in Table 2 and FGD results with stakeholders, a Causal Loop Diagram (CLD) was constructed to represent feedback relationships among variables in the LECES ecosystem. The principal causal relationships identified are as follows:

a. The higher the LECES adoption rate, the higher the material circularity rate, which in turn reduces raw material input costs and increases MSME profit margins. Higher margins incentivize more MSMEs to adopt LECES (reinforcing loop R1: Circularity–Adoption).

b. An increase in circular economic output increases green jobs through the labor multiplier coefficient. More green jobs raise household incomes, which in turn increases demand for local circular products, thereby driving higher output (reinforcing loop R2: Output–Labor–Demand).

c. An increasing number of LECES-adopting MSMEs creates capacity pressure on recycling infrastructure and local supply chains (balancing loop B1: Capacity–Infrastructure Pressure), which constrains the adoption growth rate if not offset by green infrastructure investment.

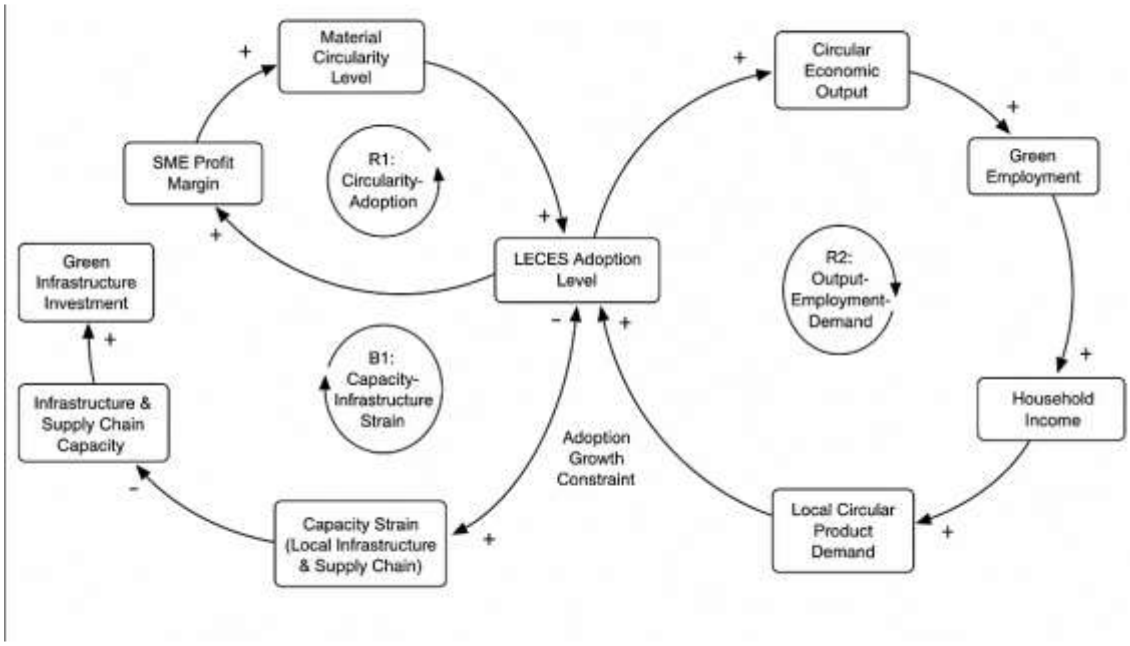

Figure 2. Causal Loop Diagram of the NTB LECES System

Source: Processed, 2026

4.2.2 Model Formulation and Stock Flow Diagram

Based on the CLD above, a Stock Flow Diagram (SFD) was constructed to represent the mathematical relationships among variables. The governing equations of the LECES dynamic model are as follows:

a. LECES adoption in year t = LECES adoption in year t−1 + Adoption diffusion rate − LECES drop-out rate.

b. Green jobs = Number of LECES adoptions × Average labor per MSME × Green job coefficient (0.62).

c. Circular economic output = Number of LECES adoptions × Average circular output value per MSME × (1 + Circularity growth rate).

d. Regional GDP contribution = Circular economic output × Regional GDP multiplier coefficient (1.43, based on the NTB input-output table).

e. The initial value of total LECES adoption is 3,847 MSME units in 2018, growing to 8,912 units in 2023. The average green job coefficient is 0.62 (62 out of every 100 jobs in LECES MSMEs meet ILO green job criteria).

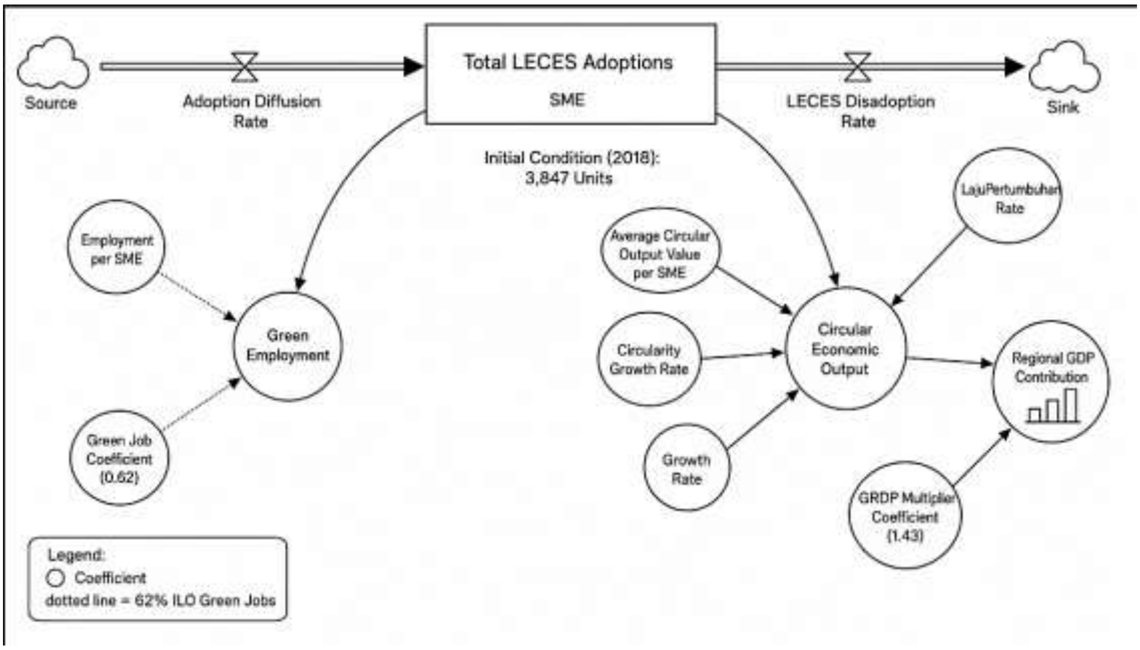

Figure 3. Stock Flow Diagram of LECES Dynamics in NTB

Source: Processed, 2026

4.2.3 Model Validation

Model validation was performed by comparing the system dynamics simulation data with empirical data for 2018–2023. The difference between the means of the actual and simulated data was tested using a two-sample independent t-test, with the null hypothesis that no significant difference exists between the two. Validation results are presented in Table 4.

Table 4. Validation Results of the LECES System Dynamics Model

Variable	Null Hypothesis	t-value	p-value
Green Jobs	No significant difference between actual and simulated mean values	0.21	0.837
Circular Economic Output	No significant difference between actual and simulated mean values	-0.38	0.714
Regional GDP Contribution	No significant difference between actual and simulated mean values	0.29	0.781

Source: Processed, 2026

As shown in Table 4, all variables yield p-values greater than 0.05, meaning the null hypothesis cannot be rejected. Accordingly, the constructed system dynamics model is statistically valid for representing the dynamics of LECES adoption and its effects on green employment and regional GDP in NTB.

4.2.4 Simulation and Sensitivity Analysis

Simulation was conducted to project the dynamics of green employment and regional GDP contribution of LECES for 2024–2030 under the baseline scenario (normal conditions). Subsequently, sensitivity analysis was performed by varying two key parameters: the material circularity rate (from 50% to 80%) and the green employment multiplier coefficient (from 0.45 to 0.75). Baseline simulation results and sensitivity analysis are presented in Figure 4 and Table 5.

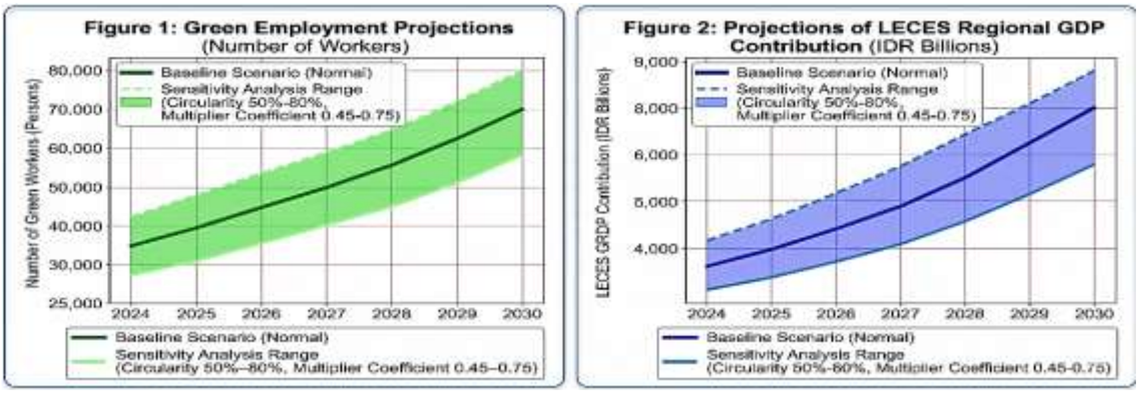

Figure 4. Projected Green Jobs and Regional GDP from LECES, 2024–2030
Source:Processed, 2026

Table 5. Sensitivity Analysis of LECES Parameters on Green Jobs and Regional GDP (Average 2024–2030)

Sensitivity Scenario	Circularity Rate (%)	Green Job Coefficient	Δ Green Jobs (%)	Δ Regional GDP (%)
Baseline	65	0.62		
Scenario 1 (Low)	50	0.45	-14.8	-10.3
Scenario 2 (Moderate)	65	0.60	-2.1	-1.4
Scenario 3 (Optimistic)	75	0.70	+18.6	+12.4
Scenario 4 (High)	80	0.75	+32.7	+21.9

Source: Processed, 2026

Table 5 reveals a sensitivity pattern consistent with international comparative studies: a 10% increase in the material circularity rate (from 65% to 75%) produces an average increase of 18.6% in green employment and 12.4% in regional GDP contribution. This reflects the strong multiplier effect of material circularity on labor intensity and economic value added, as also found by Preston (2012) and ILO (2018) in developing country contexts. Under Scenario 4 (circularity rate of 80%), the increase in green jobs reaches 32.7%, indicating that at higher circularity levels, the nonlinear effects of reinforcing loop R2 (Output–Labor–Demand) begin to dominate system dynamics.

4.3 Time-Series Modeling and LECES Projections

Following system dynamics model validation, time-series analysis was conducted to project each LECES output component separately. The following presents the best-model selection results for each component.

4.3.1 Aggregate Green Job Projection

Table 6. Green Job Projection Model Selection for NTB LECES MSMEs

Model	MAPE	MAD	MSD
Linear	4.22E+00	3.89E+02	2.17E+05
Quadratic	5.14E+00	4.61E+02	3.02E+05
Exponential-growth	6.83E+00	6.12E+02	5.47E+05
S-Curve	4.91E+00	4.23E+02	2.54E+05

Source: Processed, 2026

Based on Table 6, the best model for green job projections is the linear model, with the smallest MAPE, MAD, and MSD values. The fitted model equation is:

$$\hat{Y}t = 4{,}218 + 1{,}247T$$

where T is the time variable (T = 1 for the year 2017). The green job trend in NTB exhibits a stable linear growth pattern, reflecting an incremental and sustained LECES adoption diffusion process.

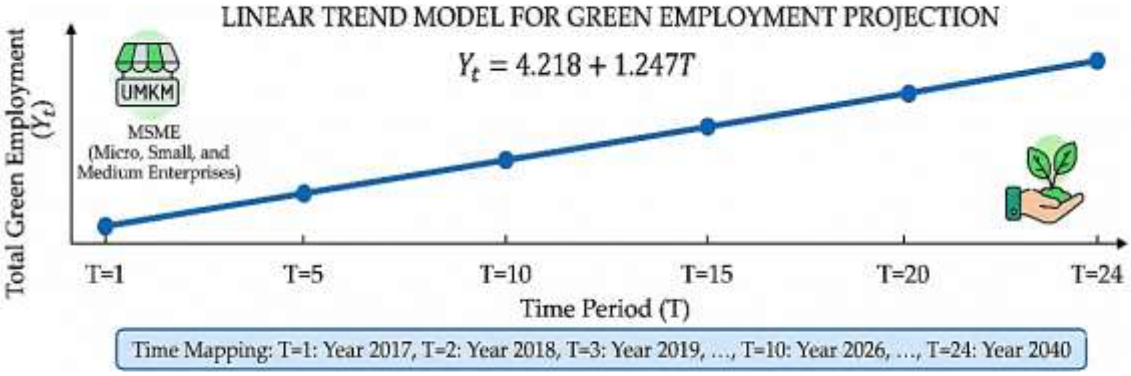

Figure 5. Green Job Trend for NTB LECES MSMEs

Source:Processed, 2026

4.3.2 Material Circularity Rate Projection

Table 7. Material Circularity Rate Projection Model Selection for NTB MSMEs

Model	MAPE	MAD	MSD
Linear	5.87E+00	3.12E+00	1.34E+01
Quadratic	4.63E+00	2.48E+00	8.71E+00
Exponential-growth	6.14E+00	3.27E+00	1.52E+01
S-Curve	3.19E+00	1.73E+00	4.29E+00

Source: Processed, 2026

The best model for projecting the material circularity rate is the S-Curve model, with the equation:

$$\hat{Y}t = 10^3 / (6.8421 + 18.7654 \times 0.7283t)$$

The selection of the S-Curve model for material circularity rate is theoretically compelling, as the diffusion of circular practices follows a logistic pattern: slow at the outset (when the innovation is unfamiliar and entry barriers are high), accelerating during the middle phase (when supportive networks and ecosystems form), and decelerating as it approaches the local system's saturation capacity (Bocken et al., 2016; Geissdoerfer et al., 2017). This S-curve trend is consistent with Blomsma and Brennan's (2017) findings on the adoption patterns of regenerative business models.

4.3.3 Circular Economic Output Value Projection

Table 8. Circular Economic Output Value Projection Model Selection for NTB LECES MSMEs

Model	MAPE	MAD	MSD
Linear	7.43E+00	1.23E+11	2.18E+22
Quadratic	5.91E+00	9.87E+10	1.32E+22
Exponential-growth	3.82E+00	6.34E+10	6.91E+21
S-Curve	4.17E+00	7.12E+10	8.43E+21

Source: Processed, 2026

The best model for projecting circular economic output value is the exponential-growth model, with the equation:

$$\hat{Y}t = 412{,}847{,}000{,}000 \times (1.1823)t$$

The exponential growth pattern in circular economic output reflects increasingly powerful multiplier effects as the LECES ecosystem develops. As more MSMEs adopt circularity, material input costs decline, market access expands, and recycling networks become more efficient generating spillover effects that drive exponential output growth (Stahel, 2016; Lacy & Rutqvist, 2015). This finding is also consistent with empirical studies in Malaysia and Vietnam's MSME sectors, which demonstrate exponential growth patterns during the acceleration phase of circular transition (de Jesus & Mendonça, 2018).

4.3.4 LECES Adoption Diffusion Projection

Table 9. LECES Adoption Diffusion Projection Model Selection among NTB MSMEs

Model	MAPE	MAD	MSD
Linear	8.21E+00	7.12E+02	7.34E+05
Quadratic	3.47E+00	2.98E+02	1.23E+05
Exponential-growth	5.93E+00	5.14E+02	4.21E+05
S-Curve	4.18E+00	3.62E+02	1.89E+05

Source: Processed, 2026

The best model for projecting LECES adoption diffusion is the **quadratic model**, with the equation:

$$\hat{Y}t = 2{,}841 + 1{,}243T + 187T^2$$

The quadratic pattern in LECES adoption diffusion indicates that the adoption rate is not merely constant but accelerates over time, reflecting imitation and social learning effects among MSMEs within the same industrial cluster. This is consistent with Rogers' (1962) diffusion of innovations theory as cited in Rizos et al. (2016), in which the early majority stage is characterized by accelerating adoption growth.

4.4 LECES Component Projections: 2024–2030

Based on the identified best-fit models, projections were made for all LECES output components for the 2024–2030 period. Table 10 presents comprehensive projections encompassing green jobs, circularity rates, circular economic output, and regional GDP contribution.

Table 10. LECES Component Projections for NTB, 2024–2030

Year	Green Jobs (persons)	LECES Adoption (MSME units)	Circular Economic Output (IDR billion)	Regional GDP Contribution (IDR trillion)
2024	9,847	12,441	1,287.4	1.84
2025	11,094	14,253	1,522.6	2.18
2026	12,341	16,439	1,800.3	2.57
2027	13,588	19,009	2,128.8	3.04
2028	14,835	21,953	2,516.7	3.60
2029	16,082	25,281	2,974.8	4.25
2030	17,329	29,003	3,517.3	5.03

Source: Processed, 2026

Table 10 demonstrates that if baseline conditions are maintained and supportive LECES policies continue to be strengthened, NTB's LECES MSMEs are projected to: (1) create more than 17,300 green jobs by 2030 an increase of 94.1% from the 2023 level of 8,912 persons; (2) involve 29,003 MSME units in the circular economy network, representing approximately 4.3% of total NTB MSMEs; (3) generate circular economic output valued at IDR 3,517.3 billion; and (4) contribute IDR 5.03 trillion to NTB's regional GDP.

4.5 Comparison of Time-Series and System Dynamics Projections

Table 11 compares green job projections using the time-series and system dynamics approaches, revealing analytically informative differences.

Table 11. Comparison of Green Job Projections: Time-Series vs. System Dynamics

Year	Time-Series (persons)	System Dynamics (persons)	Difference (%)
2024	9,847	9,412	+4.6
2025	11,094	10,318	+7.5
2026	12,341	11,287	+9.3
2027	13,588	12,314	+10.3
2028	14,835	13,401	+10.7
2029	16,082	14,548	+10.6
2030	17,329	15,753	+10.0

Source: Processed, 2026

Time-series projections consistently yield higher figures than the system dynamics projections a pattern also observed by Zulkieflimansyah et al. (2021) in NTB regional revenue projections. This difference can be conceptually explained by the fact that time-series models account only for historical trends without considering structural constraints such as recycling infrastructure capacity, supply chain limitations, or potential adoption drop-outs. In contrast, the system dynamics model integrates balancing loop mechanisms that constrain growth, thereby producing more conservative yet more realistic projections for long-term planning. Nevertheless, taken together, both approaches confirm positive and significant trends in LECES impacts on green employment and regional GDP in NTB.

CONCLUSION

5.1 Conclusions

This study provides comprehensive quantitative evidence of the impact of Locally Embedded Circular Economy Systems (LECES) implementation on green job creation and regional GDP growth in NTB Province. The principal conclusions are:

a. LECES adoption rates among NTB MSMEs exhibit significant sectoral variation. The agriculture and agro-industry sector has the highest circularity rate (68.1%), supported by a deeply rooted tradition of local resource utilization. By contrast, the fashion sector faces the greatest transition challenges owing to the complexity of textile supply chains.

b. The constructed system dynamics model was successfully validated statistically (p-value > 0.05 for all variables) and reveals two primary reinforcing loops circularity–adoption (R1) and output–labor–demand (R2) and one balancing loop infrastructure capacity (B1). Sensitivity analysis demonstrates that a 10% increase in material circularity rate produces an 18.6% increase in green employment and a 12.4% increase in regional GDP contribution.

c. The best-fit time-series models identified are the linear model for aggregate green job projections, the S-curve model for material circularity rate, the exponential-growth model for circular economic output value, and the quadratic model for LECES adoption diffusion. These patterns reflect the distinct dynamics of each dimension of the LECES system and are consistent with innovation diffusion theory and endogenous economic growth theory.

d. Combined time-series and system dynamics projections indicate that NTB's LECES MSMEs could create more than 17,300 green jobs and contribute IDR 5.03 trillion to NTB's regional GDP by 2030 a transformative potential that requires systematic policy support from the regional government.

5.2 Recommendations

Based on the findings of this study, the following policy and future research directions are recommended:

a. The NTB Provincial Government is advised to develop Regional Regulations that explicitly provide incentives for LECES-adopting MSMEs, including reductions in regional levies for certified circular MSMEs, access to low-interest green credit through regional-owned enterprises (BUMD), and streamlined business licensing for circular economy-based enterprises.

b. Priority investment in integrated recycling facilities across all districts and cities in NTB is recommended to address the bottleneck in balancing loop B1 that constrains LECES adoption growth.

c. Future research is recommended to integrate macroeconomic variables such as exchange rates, global commodity prices, and foreign direct investment into the LECES system dynamics model, so that projections are not solely dependent on temporal factors and internal dynamics.

d. Broader comparative studies across provinces in Eastern Indonesia using a similar system dynamics modeling approach are strongly recommended to generate regionally generalizable policy recommendations.

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