

Urban Farming for Village Food Security: Utilizing Land Beneath Electricity Transmission Lines

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ABSTRACT

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Mahadewa, V. A., Miraza, R. M., Kandioh, B., & Pradipta, G. (2026). Urban farming for underused land beneath electricity village food security: Utilizing land beneath transmission lines and support local food electricity transmission lines. *Journal of the security*. Using a descriptive qualitative approach, data were collected through observation, interviews, and document analysis, with outcomes assessed using the Sustainability Compass framework. The findings show that 4,340 m² of previously underutilized land was transformed into an integrated circular production system comprising organic farming, freshwater aquaculture, fishery-based MSMEs, and a waste bank. The program generated multidimensional outcomes across the four Sustainability Compass dimensions: Nature through waste recovery and productive land utilization; Economy through income-generating activities and production-cost savings; Well-being through improved access to locally produced food and the direct engagement of 33 community members; and Social outcomes through institutional strengthening and community resilience. Integrating circular economy principles into community-based urban farming can transform underutilized land into productive assets and strengthen local food security.

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INTRODUCTION

Global food security is increasingly challenged by population growth, climate change, resource scarcity, and inefficiencies in conventional food systems. The prevailing linear economic model, characterized by a take-make-dispose pattern, contributes to resource depletion and waste generation and creates additional pressures on the sustainability of food systems (Araújo et al., 2023). In this context, the circular economy (CE) has emerged as an alternative framework that emphasizes resource efficiency, waste reduction, resource recovery, and the retention of resource value within production and consumption systems (Sindhu et al., 2023). In food systems, these principles provide opportunities to reconnect production, consumption, and waste management in ways that can generate environmental and economic value while supporting food security.

Previous studies have demonstrated the potential of CE to address food-system challenges through food waste recovery, organic farming, resource-efficient production, and the conversion of residual materials into productive inputs (Craparo et al., 2024; Pakravan-Charvadeh, 2026; Wang et al., 2021). At the community level, such approaches can create opportunities to utilize local resources more efficiently while supporting livelihoods and environmental sustainability. However, the implementation of CE in food systems is not limited to technological or waste-management interventions. Its effectiveness also depends on how circular practices are organized at the community level, how different productive activities are interconnected, and how local actors participate in creating and retaining value from available resources.

Despite the growing literature on CE and sustainable food systems, there remains limited empirical understanding of how CE principles are operationalized through integrated, community-based urban farming systems, particularly in the Indonesian context. Existing discussions tend to examine individual elements of circularity, such as waste recovery, organic farming, resource efficiency, or food production, rather than examining how these elements can be integrated into a community-based system that simultaneously addresses land constraints, livelihood opportunities, and local food security. This gap is particularly relevant in urban and peri-urban areas, where access to productive land is increasingly constrained and alternative forms of land utilization are needed to support community-based food production.

The Inclusive People's Economic Empowerment Program through Urban E-Farming around Transmission Lines (*Program Pemberdayaan Ekonomi Rakyat Inklusif melalui Urban E-Farming sekitar Jalur Transmisi* or PERISAI NEGERI Program) initiative provides a relevant empirical case for examining this issue. The program utilizes previously underused land beneath an electricity transmission corridor in Wanajaya Village, Bekasi Regency, and integrates organic farming, freshwater aquaculture, fishery-based micro, small, and medium enterprises (MSMEs), and waste-bank activities within a community-based empowerment approach. Rather than treating these activities as separate interventions, the program connects resource use, production, waste recovery, and economic activities to create a local circular system. This configuration makes the case relevant for examining how CE principles can be translated into practice through urban e-farming and community participation, particularly in a context where productive land is limited.

Against this background, this study examines the concept, implementation, and outcomes of a community-based urban e-farming initiative based on CE principles and its contribution to local food security. The study contributes to the literature by illustrating how underutilized land can be incorporated into an integrated circular production system that links food production, resource recovery, livelihood generation, and community

institutional development. By examining the case through the Sustainability Compass dimensions of nature, economy, well-being, and social outcomes, the study further provides an integrated perspective on the multidimensional contributions of community-based CE practices to local food-system sustainability.

LITERATURE REVIEW

Circular Economy (CE)

The CE provides an alternative to the conventional linear model of production and consumption by emphasizing resource efficiency, waste reduction, recovery, and the circulation of resources within interconnected systems. In the context of urban food systems, these principles are particularly relevant because cities simultaneously generate large volumes of organic waste and face increasing demands for food, land, water, and energy. Urban agriculture therefore offers a potential setting for operationalizing circularity by reconnecting food production with resource recovery and local consumption. Studies have shown that urban agriculture can contribute to circular resource flows through the reuse of organic materials, efficient resource management, and the integration of agricultural production with other urban systems (Piezer et al., 2019; Riaño-Herrera et al., 2023; Rufi-Salís et al., 2021). More recent research also indicates that urban agriculture can function as a nature-based solution for promoting circularity by linking food production with environmental management and local resource use (Ioannides et al., 2025). In the agricultural sector more broadly, the transition toward circularity similarly requires the integration of production, resource recovery, and regional development rather than treating individual agricultural activities as isolated interventions (Mulya et al., 2025). However, the implementation of circular economy practices in food and agri-food systems may also be influenced by institutional, organizational, and stakeholder-related drivers and barriers, highlighting the importance of understanding how circular initiatives are coordinated and implemented in specific local contexts (Banerjee et al., 2026).

Community Empowerment and Urban Farming

The circularity of urban farming, however, is not determined solely by the technical capacity to reuse resources. It also depends on the participation and capabilities of the communities that organize, operate, and sustain these activities. Urban farming can provide a platform for community empowerment by creating opportunities for collective action, livelihood development, knowledge exchange, and local resource management (Goenadhi, 2022; Kurniawan et al., 2022). Atmaja et al. (2021), for example, demonstrate the role of urban farming in strengthening community resilience and empowerment, while Yuniarsih et al. (2026) emphasize the importance of community participation in connecting urban agriculture with livelihood and sustainability outcomes. A systematic review by Mirza et al. (2025) further positions urban agriculture as a multidimensional practice associated with environmental, economic, and social sustainability. These findings suggest that community empowerment should not be regarded merely as an additional social benefit of urban farming; rather, it can constitute an important mechanism through which circular practices are collectively implemented and maintained. Consequently, community-based urban farming provides a link between the material dimension of CE—represented by the circulation of resources—and the social dimension represented by participation, collective capacity, and local development.

Food Security

The integration of CE principles into urban agriculture also creates potential pathways toward local food security by improving resource efficiency, reducing waste, and supporting more sustainable food-production systems (Agaja & Olaniran, 2025). Urban agriculture can increase the proximity of food production to consumers, utilize otherwise

underused urban spaces, and reduce dependence on distant food-supply systems. When combined with circular practices, these functions can be strengthened through the recovery and reuse of resources, reduction of food waste, and integration of different productive activities. [Porpino et al. \(2025\)](#), through their study of circular food-system transitions in Brazilian municipalities, highlight the importance of stakeholder involvement in transforming food systems toward greater circularity. Similarly, [Stuiver and O'Hara \(2021\)](#) conceptualize urban food systems as potential centers of a CE, in which food production, consumption, waste, and other urban activities become interconnected rather than operating as separate linear processes. The relationship between circularity and food security can therefore be understood through several interconnected pathways: circular production can support local food availability, resource efficiency can strengthen the resilience of food production, and community-based economic activities can potentially improve people's capacity to access food.

This relationship also indicates that food security should not be interpreted solely in terms of the quantity of food produced. Circular urban farming connects food production with economic, environmental, and social conditions that influence the sustainability of local food systems. The food-energy-water nexus literature, for example, demonstrates that food production is closely interconnected with resource availability and environmental management ([Calus-Makowska et al., 2025](#); [Verma et al., 2024](#)). Likewise, research on agricultural bioeconomy and recycling emphasizes the importance of integrating biomass production, resource recovery, and circular resource use in developing more sustainable agricultural systems ([Toplicean & Datcu, 2024](#)). Thus, the contribution of urban farming to food security needs to be considered within a broader system in which food production, resource use, environmental conditions, livelihoods, and community capacities interact. This perspective is particularly relevant for community-based initiatives that seek to transform underused land into productive spaces while simultaneously connecting agriculture, aquaculture, waste management, and local economic activities.

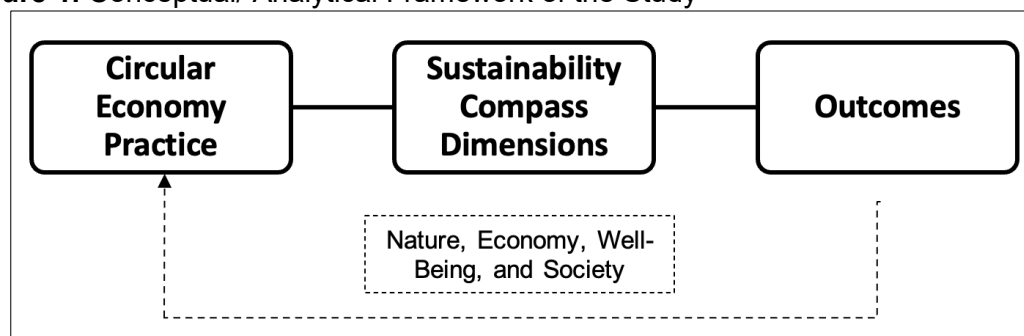
Sustainability Compass as an Analytical Lens

The multidimensional relationships identified in the literature require an analytical framework capable of examining environmental, economic, social, and human outcomes simultaneously. Sustainability assessment approaches increasingly emphasize the need to move beyond single-dimensional measures of environmental or economic performance toward integrated assessments of interconnected systems ([Federico et al., 2023](#); [Rufi-Salís et al., 2021](#)). In this study, the Sustainability Compass is used as an analytical lens to organize these multidimensional outcomes into four dimensions: Nature, Economy, Well-being, and Society ([Atkisson & Hatcher, 2001](#)). The Nature dimension captures changes associated with resource efficiency, waste reduction, and environmental management; Economy concerns productive activities, income generation, and economic value; Well-being concerns benefits related to food and quality of life; while Society encompasses participation, institutional development, collective capacity, and community resilience. The framework therefore provides a way to connect the material circularity of resource flows with the broader social and developmental outcomes generated through community-based urban farming.

Viewed through this framework, the relationship among CE, community empowerment, urban farming, and food security can be conceptualized as an interconnected system rather than a linear sequence of independent interventions. CE practices provide the principles and mechanisms for improving resource circulation and reducing waste; community empowerment provides the social capacity to organize and sustain these practices; and urban farming provides a productive setting in which circular resource flows can be implemented. These processes may contribute to local food security

through improved food production, resource resilience, and community-based economic activities, while also generating broader environmental, economic, social, and well-being outcomes. The Sustainability Compass provides an integrated analytical perspective for examining these outcomes across the four dimensions of Nature, Economy, Well-being, and Society. Accordingly, the present study conceptualizes community-based urban farming as a practical arena for translating CE principles into local food-system practices and uses the Sustainability Compass to assess their multidimensional contributions to local food security and sustainable community development (see Figure 1).

Figure 1. Conceptual/ Analytical Framework of the Study



RESEARCH METHOD

Research Design

This study employed a qualitative case study approach to develop an in-depth understanding of the implementation and outcomes of a community-based urban e-farming initiative based on CE principles. The case examined was the PERISAI NEGERI Program, implemented in Wanajaya Village, Cibitung District, Bekasi Regency. The case was selected because it integrates several productive activities, including organic farming, freshwater aquaculture, fishery-based MSMEs, and waste-bank management within a community-based land-utilization initiative. The analysis focused on three aspects: (1) the implementation of CE principles, (2) the processes through which the program was implemented at the community level, and (3) the multidimensional outcomes generated by the program.

Research Location and Period

The study was conducted in Wanajaya Village, Cibitung District, Bekasi Regency, West Java, Indonesia. The location was selected because it is the site of the community-based urban e-farming initiative examined in this study, which utilizes previously underused land beneath an electricity transmission corridor for integrated productive activities. The study analyzed program implementation and outcome data covering the period from January 2025 to May 2026. During this period, the analysis focused on the development and implementation of the urban e-farming activities, including organic farming, freshwater aquaculture, MSME development, and waste-bank management. Data were obtained through interviews, field observations, and document analysis to capture the development of the program and its outcomes over the study period.

Informants and Sampling

Informants were selected using purposive sampling based on their knowledge, experience, and direct involvement in the program. Four informants participated in the study, with one representative selected from each relevant stakeholder group, namely the program/company representative, community or beneficiary-group representative, local government representative, and other relevant stakeholder involved in the program (see Table 1).

Table 1. Informant and Sampling

No.	Informant	Representation
1	Informant 1 (I1)	Beneficiary representative
2	Informant 2 (I2)	Local government representative
3	Informant 3 (I3)	Village government representative
4	Informant 4 (I4)	Corporate representative

Informants were selected according to the following criteria: (1) direct involvement in program planning, implementation, management, or monitoring; (2) participation in or direct knowledge of the program activities; and (3) possession of relevant institutional or contextual information concerning the implementation and outcomes of the program. The identification and selection of informants were conducted purposively to ensure that each stakeholder perspective relevant to the case was represented. Given the focused case-study design and the complementary use of observation and documentary evidence, interview information was triangulated across the four informants and other data sources to strengthen the credibility of the findings.

Data Collection

Data were collected through in-depth interviews, participatory observation, and document analysis (see Table 2). In-depth interviews were conducted using a semi-structured interview guide covering the program rationale, planning and implementation processes, community participation, CE practices, perceived benefits, and challenges encountered during implementation. Interviews were conducted with selected informants according to their roles and experiences in the program.

Table 2. Data Collection

No.	Data Collection Technique	Data Type
1	In-Depth Interviews	Program rationale, implementation processes, community participation, circular-economy practices, perceived benefits, and implementation challenges
2	Participatory Observation	Physical conditions, community activities, farming and aquaculture practices, waste-management activities, and community interactions
3	Document Analysis	Program implementation reports, evaluation reports, financial/sales records, institutional documents, and supporting program documentation

Data Analysis

Data were analyzed using the interactive model of Miles and Huberman, consisting of data collection, data reduction, data display, and conclusion drawing. Data collection and analysis were conducted iteratively throughout the research process. During data reduction, interview transcripts, observation notes, and documents were organized according to themes related to CE practices, community implementation, food security, and program outcomes. Relevant information was subsequently displayed in thematic matrices to facilitate comparison across informants and data sources. Conclusions were developed through the identification of recurring patterns, relationships, and explanations and were continuously checked against the available evidence.

The Sustainability Compass was applied as an analytical lens to organize and interpret the multidimensional outcomes of the program. The analysis categorized empirical findings into four dimensions: Nature, Economy, Well-being, and Society. The Nature

dimension was used to examine environmental outcomes such as resource efficiency, waste reduction, and productive land utilization. The Economy dimension captured economic outcomes associated with productive activities, business development, and revenue generation. The Well-being dimension focused on benefits related to food provision and community welfare, while the Society dimension examined participation, institutional development, collective capacity, and community resilience. This framework enabled the researchers to examine the contribution of CE practices beyond economic outcomes alone.

Data Validity

The credibility of the findings was strengthened through source triangulation and methodological triangulation. Information obtained from different categories of informants was compared with evidence from observations and program documents. Where quantitative information was reported in the Results, the figures were cross-checked against relevant program records and supporting documents and, where appropriate, compared with information obtained through interviews and field observations. Differences or inconsistencies between sources were reviewed during the analysis process before the information was incorporated into the findings. This process was used to ensure that the interpretation of program implementation and outcomes was grounded in evidence from multiple sources.

RESULTS

CE Concepts and Ideas for Achieving Food Security

The CE has emerged as an alternative paradigm in sustainable development, offering a systemic approach to managing resources more efficiently and sustainably. Unlike the linear economic model, which follows a take-make-dispose pattern, the CE emphasizes resource reuse, waste reduction, material recovery, and the regeneration of natural systems through resource-looping mechanisms. Through this approach, the value of resources is retained within the economic cycle for as long as possible, thereby reducing environmental pressures while improving resource-use efficiency. In the context of community development, the CE is understood not only as a waste management strategy but also as an empowerment model capable of creating new economic value from previously underutilized resources.

This initiative was realized through the PERISAI NEGERI Program. The program was developed as a community economic empowerment strategy by optimizing local potential and transforming 4,340 square meters of underutilized land into a productive area capable of generating sustainable economic, social, and environmental benefits (Interview with I4). The program was initiated in response to a common challenge faced by urban areas: the limited availability of land that can be utilized to support community-based economic activities. This constraint often hinders the implementation of empowerment initiatives that rely on the effective use of local resources.

To address this challenge, the Company collaborated with the Wanajaya Village community to transform previously unused land beneath the power transmission lines into a productive urban e-farming area (Figure 2). The use of this land is governed by a written agreement between the Company and the community group, providing clear arrangements regarding land use rights, responsibilities, and management mechanisms. Through this community-based empowerment approach, the PERISAI NEGERI Program aims not only to increase community income but also to strengthen institutional capacity, promote local economic self-reliance, and foster more productive, inclusive, and sustainable resource management in areas surrounding the transmission corridor.

Figure 2. Organic Farming Area Beneath the Company's Transmission Line Corridor



The principle of circularity in the PERISAI NEGERI Program is implemented through the synergy of four main components: organic farming, freshwater fish farming (Figure 3), the development of fishery-based MSME products, and a waste bank. The integration of these components creates mutually reinforcing relationships that enable the repeated use of resources while minimizing waste. One tangible example of CE implementation within the program is the use of a recirculation system in the aquaculture unit, which improves water-use efficiency and reduces resource waste. In addition, the presence of the waste bank and the processing of fishery products into MSME products demonstrate efforts to create added value from available resources, thereby fostering a more productive, inclusive, and sustainable local economic ecosystem.

Figure 3. Freshwater Fish Farming Activities



The PERISAI NEGERI Program embodies the principles of the CE by shifting waste management practices from the traditional linear model (take–make–dispose) to a circular approach that emphasizes the principles of reduce, reuse, recycle, and regenerate. The program was developed in response to the increasing volume of organic waste generated by the operations of PT Cikarang Listrindo Combined Cycle Power Plant (CCPP), which reached approximately 5,370 tonnes in 2025. At the same time, the closure of the Burangkeng Final Disposal Site (TPA Burangkeng) required the Company to independently manage its domestic waste in accordance with Government Regulation No. 27 of 2020 (Interview with I2). These circumstances prompted the Company to develop an integrated waste management system that not only ensures regulatory

compliance but also creates added value for both the environment and surrounding communities.

At the same time, the Bekasi Regency Government was also facing challenges in waste management, which had an impact on Wanajaya Village. Limited waste management capacity led to an increase in open dumping practices across residential areas, resulting in sanitation issues and declining environmental quality. In response to these challenges, the Company recognized that waste management could not be addressed through a fragmented approach but required active community participation as a key component of the solution. Accordingly, the Company conducted community education on the potential of waste, particularly organic waste, as a resource that can be processed into compost and other value-added products with both economic and environmental benefits.

As a learning initiative, the Company first implemented the practice of processing organic waste into compost to support the organic farming activities developed under the PERISAI NEGERI Program. This approach reflects the principle of resource recovery, whereby waste is transformed into valuable resources, enabling materials previously regarded as residual waste to be reused for productive purposes. Following the successful implementation of this practice, the Company replicated the approach within the community through mentoring activities and the establishment of a waste bank as a local institution responsible for managing household waste (Figure 4). Through this institution, community members are encouraged to sort, process, and utilize waste to produce value-added products, creating a CE that not only reduces waste generation but also strengthens local economic self-reliance and enhances the village's environmental quality.

Figure 4. Plastic Waste Weighing Activities at the Waste Bank Unit



Instead of disposing of organic waste in landfills, the company processes it into compost, which serves as the primary input for its CE system. At this stage, a resource recovery process takes place, whereby value is recovered from waste, allowing materials that were previously considered of little or no value to be transformed into productive resources once again. The compost is subsequently utilized in urban farming and greening activities within the company's premises and in areas surrounding the electricity transmission lines through the PERISAI NEGERI Program. These activities generate various ecological benefits, including improved land quality, increased green coverage, and enhanced protection of transmission network assets through managed vegetation

planting. Thus, organic waste does not merely undergo recycling but is also reintroduced into the production cycle as an input for agricultural activities.

Circular value is further enhanced through the involvement of local communities as key actors in managing waste and utilizing the outputs of waste processing. Through the empowerment program, community members received training in non-hazardous and non-toxic waste management, the establishment of waste banks, the development of independent wastewater treatment facilities, and the adoption of environmentally friendly technologies. These included the installation of a solar photovoltaic (PV) power system at the fish feed facility, which reduced monthly electricity costs by approximately 20%. These interventions strengthened the community's capacity to develop a more efficient and sustainable local economic system.

Within the program's value chain, the compost produced is further processed into liquid organic fertilizer (LOF) and compost fertilizer, both of which have higher economic value. These products were initially used to meet the community's agricultural needs in 2025 and are planned for commercialization beginning in 2026 (Interview with I1). This stage demonstrates a process of value creation, in which the added value of waste is increased through product innovation, thereby creating new business opportunities and sources of income for the community.

The empowerment program stimulated local economic development by expanding community-based livelihood opportunities through four business units: fisheries, organic farming, MSMEs, and a waste bank (Interview with I1). Between 2025 and May 2026, these business units generated a combined sales revenue of IDR 145,251,790. The fisheries unit accounted for the largest share, producing 2,817 kg of catfish with a total sales value of IDR 70,425,000, followed by the MSME unit (IDR 37,145,000), the organic farming unit (IDR 28,072,500), and the waste bank (IDR 9,609,290). Beyond increasing sales revenue, the program also improved economic efficiency by replacing chemical fertilizers with compost fertilizer, resulting in production cost savings of approximately IDR 10,500,000 per month. Moreover, MSME products have obtained Halal certification and the PIRT (Home Industry Food Production) license, enhancing product credibility and expanding market opportunities. To ensure the continuity of program benefits, profits generated from all business units are assessed annually and reinvested in the development of facilities and infrastructure that support long-term program sustainability (Safira & Zakiyyah, 2025).

Overall, the CE concept implemented through the PERISAI NEGERI Program forms a closed-loop system in which the company's organic waste is processed into compost, which is subsequently used for agriculture and urban farming. This process generates products with economic value, namely compost and LOF, which can contribute to improving community welfare while strengthening the community's capacity for waste management. Ultimately, the program can further support the reduction of waste generated by the company. This cycle demonstrates that waste is no longer viewed as residual material that must be discarded, but rather as a resource whose value is continuously retained through reuse and further utilization.

Implementation of the CE in Achieving Food Security

The PERISAI NEGERI Program was implemented through a series of activities designed to strengthen community capacity while building a community-based CE ecosystem. One of the main strategies involved capacity-building activities through integrated training aimed at improving the community's knowledge, skills, and awareness in managing local resources productively and sustainably. These efforts included Organic Waste Processing Training, which involved various stakeholders, including Yayasan

Kumala, the Bekasi Regency Environmental Agency, the PERISAI NEGERI Group, and the Wanajaya Village Government. This multi-stakeholder collaboration not only strengthened knowledge transfer in organic waste management but also encouraged the development of institutional networks that support CE practices at the community level. In addition, the program organized benchmarking visits to a national pilot site to provide participants with direct learning experiences regarding best practices in community-based program management. This activity involved PLN Indonesia Power UPB Bali, Mutual Self-Help Group (*Kelompok Swadaya Bersama* or KSB) Karang Kemanisan, Karang Kemanisan Urban Village, and the PERISAI NEGERI Group as learning participants. Through this activity, community members gained insights into community enterprise management models, institutional strengthening, and program sustainability strategies that have been successfully implemented in other regions.

In addition to strengthening human resource capacity, the PERISAI NEGERI Program also focused on enhancing the business capacity of community groups through the provision of infrastructure, facilities, and equipment to support productive economic activities. In the freshwater aquaculture sector, the program improved aquaculture infrastructure with the aim of increasing business productivity, enhancing resource management efficiency, and improving the quality of production outputs. Efforts to strengthen the local economy were also carried out through the development and improvement of infrastructure for the waste bank unit and the organic farming area.

Multidimensional Outcomes of CE Implementation

Based on an analysis using the Sustainability Compass framework, the PERISAI NEGERI Program demonstrated positive contributions across four dimensions of sustainability: nature, economy, well-being, and social. In the nature dimension, the program contributed to environmental conservation through the management of one waste bank unit and the utilization of 4,340 square meters of idle land for organic farming and aquaculture activities. The program also implemented a solar PV system comprising a 250 Wp PV module, an 850 VA inverter, and a 100 Ah, 12 V battery. The battery had a nominal capacity of 1,200 Wh, with an estimated effective usable capacity of 0.84 kWh based on a 70% utilization level. In addition, 70 waste bank customers contributed to reducing the amount of waste sent to landfills by 149.4 kg per month. Quantitatively, the use of organic fertilizers as a substitute for chemical fertilizers resulted in carbon sequestration of 15.884 tonnes of CO₂ per year (Safira & Zakiyyah, 2025).

In the economic dimension, the program created new economic opportunities through four community business units: fisheries, organic farming, MSMEs, and a waste bank. During 2025, these business units generated total sales revenue of IDR 99,671,720, while sales during January–May 2026 reached IDR 45,580,070. Thus, the combined recorded sales during the period January 2025–May 2026 amounted to IDR 145,251,790. The fisheries unit made the largest contribution, generating IDR 70,425,000 across the two reporting periods, followed by the MSME, organic farming, and waste-bank units. In addition to sales revenue, the use of compost fertilizer generated reported production-cost savings of approximately IDR 10,500,000 per month. In addition to generating revenue, the program produced economic benefits by reducing production costs through the use of compost fertilizer, resulting in monthly savings of approximately IDR 10,500,000. Furthermore, the MSME products have obtained Halal certification and the PIRT (Home Industry Food Production) license, enabling broader market access and strengthening consumer confidence. The profit generated by all business units is calculated annually and reinvested into the program to support business expansion, particularly through the development of facilities and infrastructure that enhance the program's long-term sustainability (Safira & Zakiyyah, 2025).

In the well-being dimension, the program contributed to improving the quality of life of local communities by providing access to healthy, locally produced food and directly empowering 33 community members involved in various program activities. In the social dimension, the program successfully strengthened community capacity and institutions through the establishment of four business groups in agriculture, aquaculture, MSMEs, and waste bank management. The agriculture, aquaculture, and waste bank groups obtained formal legal recognition through decrees issued by the Wanajaya Village Government. In addition, group members participated in various capacity-building activities, including training on agricultural potential development and disaster preparedness training, given the area's vulnerability to flooding. They also participated in a benchmarking visit to Kampung Siaga Bencana Karang Kemanisan as part of efforts to strengthen community resilience to disaster risks.

Table 3. Outcomes of the PERISAI NEGERI Program

Sustainability Dimension	Indicator	PERISAI NEGERI Program Outcomes
Nature (Environmental)	Waste Management	The waste bank serves 70 registered members and manages 149.4 kg of waste per month, contributing to the reduction of waste disposed of in landfills.
	Land Utilization	Optimized 4,340 m ² of previously idle land beneath the electricity transmission corridor for organic farming and aquaculture activities.
	Renewable Energy	Utilized a solar PV system consisting of a 250 Wp PV module, an 850 VA inverter, and a 100 Ah, 12 V battery with a nominal capacity of 1.2 kWh and an estimated usable capacity of 0.84 kWh. The system reduced monthly electricity costs by approximately 20%.
	Emission Reduction	The use of organic fertilizer as a substitute for chemical fertilizer contributed to carbon sequestration of 15.884 tCO ₂ /year.
Economy (Economic)	Business Units	Established four community business units: organic farming, fisheries, MSMEs, and a waste bank.
	Sales Revenue (2025)	Total sales revenue reached IDR 99,671,720, comprising fisheries (IDR 47,800,000), organic farming (IDR 20,847,000), MSMEs (IDR 25,030,000), and the waste bank (IDR 5,994,720).
	Sales Revenue (January–May 2026)	Total sales revenue reached IDR 45,580,070, comprising fisheries (IDR 22,625,000), organic farming (IDR 7,225,500), MSMEs (IDR 12,115,000), and the waste bank (IDR 3,614,570).
	Cost Efficiency	The use of compost fertilizer generated cost savings of IDR 10,500,000 per month.
	Product Competitiveness	MSME products obtained Halal certification and the PIRT (Home Industry Food Production) license.
Well-being	Food Access	Improved community access to healthy food through organic farming and fish cultivation.

Sustainability Dimension	Indicator	PERISAI NEGERI Program Outcomes
	Community Empowerment	Directly engaged 33 community members in various program activities.
Social	Institutional Strengthening	Established four community business groups: organic farming, fisheries, MSMEs, and a waste bank.
	Institutional Legitimacy	The organic farming, fisheries, and waste bank groups obtained official recognition through Village Government Decrees issued by the Wanajaya Village Government.
	Capacity Building	Conducted training on agricultural development, disaster preparedness, and benchmarking visits to the Karang Kemanisan Disaster Preparedness Village.
	Community Resilience	Strengthened community capacity to cope with flood risks through institutional strengthening and inter-community learning.

Source: Implementation Report (2025)

According to [Table 3](#), the findings indicate that the PERISAI NEGERI Program has the potential to contribute to local food security through several pathways. The utilization of previously underused land for urban farming and aquaculture expanded opportunities for local food production, particularly through the cultivation of vegetables and freshwater fish (Interview with I3). The income generated from the community business units may also support household capacity to access food, although this study did not directly measure changes in household food expenditure or purchasing power. In terms of food utilization, the production of fish and agricultural products provided additional sources of locally produced food. These findings suggest that the program contributes to several dimensions associated with local food security, particularly through increased local food production and livelihood opportunities. However, the study does not claim to establish a statistically significant improvement in household food security because a standardized food-security measurement was not employed.

DISCUSSION

Key Findings Analysis

CE as a Community-Based Food-System Model

The PERISAI NEGERI Program demonstrates how the abstract concept of the CE can be translated into a practical model of community-level action. CE has often been criticized for conceptual ambiguity and for being predominantly oriented toward large-scale industrial applications, which can make its application at the grassroots level less evident ([Romic, 2025](#)). The optimization of 4,340 square meters of previously underused land beneath the transmission lines, however, illustrates how circularity principles can be applied at a micro-local scale ([Gama et al., 2017](#); [Koech & Munene, 2019](#)). The integration of organic farming, freshwater aquaculture, fishery-based MSMEs, and a waste bank further extends the understanding of CE beyond an exclusive focus on downstream waste management ([Sindhu et al., 2023](#)). The interconnected activities create opportunities for resource circulation, including the use of organic waste as an input for farming and the recirculation of water within aquaculture activities ([Dieguez-Santana et al., 2025](#); [Roy et al., 2025](#)).

These findings are consistent with previous studies that position urban agriculture as a potential mechanism for closing resource loops ([Piezer et al., 2019](#); [Rufi-Salis et al.,](#)

2021; Riaño-Herrera et al., 2023), but they also extend this perspective by demonstrating how circularity can be embedded within a community empowerment initiative that simultaneously combines food production, waste management, and livelihood activities. The contribution of the case therefore lies not simply in demonstrating that circular practices can occur at a small scale, but in showing how different productive activities can be institutionally connected within a community-based food system. However, the observed integration should be understood as evidence of an emerging local circularity model rather than as evidence that the program has established a fully closed-loop system or achieved complete food self-reliance.

Capacity Building and Collaborative Governance

In terms of implementation, the findings indicate that capacity building and collaborative governance were important enabling conditions for implementing circular practices in the community. Previous studies have identified cultural resistance, limited knowledge, and fragmented policies as important barriers to the transition toward circularity (Giorgi et al., 2022; Romic, 2025). In Wanajaya Village, these challenges were addressed through multi-stakeholder collaboration involving Yayasan Kumala, the Bekasi Regency Environmental Agency, the Village Government, and other program actors. This finding is consistent with Doukas et al. (2026), who emphasize the importance of institutional and policy coordination in improving the sustainability of food systems.

The benchmarking activities conducted at national pilot sites also illustrate the role of knowledge exchange and social learning in supporting community-level adoption of circular practices (Nordin et al., 2022). In this case, knowledge transfer was accompanied by the development of physical infrastructure for aquaculture and organic farming. This combination suggests that capacity building is more likely to support circular practices when knowledge is accompanied by opportunities and facilities through which that knowledge can be applied. Thus, the case extends previous discussions of circular-economy adoption by highlighting the interaction between social learning, institutional collaboration, and enabling infrastructure. These elements should therefore be considered complementary rather than independent interventions in community-level circular-economy initiatives.

Sustainability Compass and the Multidimensional Outcomes of Circularity

The Sustainability Compass provides a useful analytical lens for interpreting the outcomes of the program because CE initiatives generate consequences that extend beyond resource recovery and economic activity. In the present case, circular practices were associated with environmental resource management, economic value creation, food-related benefits, and institutional and community development. These outcomes correspond to the four dimensions of the Sustainability Compass—Nature, Economy, Well-being, and Society. The following sections discuss each dimension by connecting the empirical findings with relevant literature and considering how the case confirms, extends, or qualifies existing understandings of community-based circularity.

In the Nature dimension, the waste bank managed approximately 149.4 kg of waste per month, while organic waste and other recoverable materials were incorporated into local resource-management activities. These findings are consistent with the broader CE literature, which emphasizes the importance of reducing waste and maintaining resources within productive cycles (Wang et al., 2021). Rather than treating waste solely as an end-of-pipe problem, the program created opportunities for waste to become an input within other community activities, particularly organic farming. In this sense, the findings support the argument that urban agriculture can function as a nature-based mechanism for strengthening circularity by connecting resource recovery with food production (Ioannides et al., 2025; Rufi-Salís et al., 2021).

In the Economy dimension, the four community business units generated recorded sales of IDR 145,251,790 during January 2025–May 2026, comprising fisheries, organic farming, MSMEs, and the waste bank. These economic activities indicate that circularity in this case was not limited to environmental resource recovery but was also connected to livelihood generation and local economic activities. This finding extends conventional interpretations of CE by demonstrating how resource-looping mechanisms can be embedded within community-based productive activities. The use of compost and other locally available resources also created opportunities to reduce dependence on external production inputs. However, these findings should be interpreted as evidence of economic activity and value creation rather than as definitive evidence that the program caused an improvement in household economic welfare, particularly because the study did not employ a counterfactual or longitudinal impact-assessment design.

The integration of solar PV systems also illustrates the role of green technology in supporting the circularity of the local production system. Rather than interpreting the technology solely in terms of energy efficiency, its relevance lies in its function as supporting infrastructure for community-based production activities. This finding is consistent with studies emphasizing the importance of green technologies in facilitating more resource-efficient food and production systems (Kashyap et al., 2026; Tanveer et al., 2022). Taken together, the Nature and Economy dimensions suggest that environmental resource recovery and economic value creation can operate as interconnected processes within a community-level CE model.

The Well-being dimension highlights the food-related and welfare-oriented benefits observed among participating community members. The involvement of 33 community members and the availability of locally produced agricultural and fishery products created an additional source of food within the community. This finding is consistent with studies associating urban agriculture with local food access, livelihoods, and community well-being (Nowicki et al., 2019; Sindhu et al., 2023). From the Sustainability Compass perspective, the significance of this finding lies in showing that the contribution of circularity cannot be assessed solely through material flows or economic returns; it also involves the extent to which productive activities generate tangible benefits for people participating in the system.

Nevertheless, the present study does not establish a statistically measurable improvement in household food security because a standardized food-security assessment was not conducted. The findings therefore indicate a potential pathway through which community-based circular urban farming may support local food security, particularly through local food production and access, rather than demonstrating a causal improvement in household food-security status.

The Society dimension highlights the institutional and collective conditions through which circular practices can be organized and sustained. The formal recognition of community business groups through decrees issued by the Wanajaya Village Government, together with the involvement of community members and multiple institutional actors, indicates that the program was accompanied by processes of participation and institutionalization. These findings are consistent with studies emphasizing the role of urban agriculture in strengthening participation, livelihoods, and community resilience (Atmaja et al., 2021; Yuniarsih et al., 2026). The case extends this perspective by suggesting that the social dimension of circularity involves more than the number of participants; it also encompasses institutional recognition, collective organization, and the capacity of local actors to coordinate productive activities.

The flood-disaster preparedness training further illustrates how community-based circular initiatives may generate social value beyond their immediate productive functions. In contexts vulnerable to environmental disruption, food security is closely connected to the capacity of communities to respond and adapt to climate-related pressures (Brenya et al., 2024; Pakravan-Charvadeh, 2026). The findings therefore suggest that institutional capacity and disaster preparedness can function as supportive conditions for maintaining community-based food and livelihood activities under environmental pressures. This should not be interpreted as evidence that the program directly caused greater community resilience; rather, the case indicates that resilience-building activities can complement circular food-system initiatives and broaden their social significance.

Theoretical and Practical Implications

Taken together, the findings provide both theoretical and practical implications. Theoretically, the case extends the application of the CE concept from industrial and waste-management contexts toward a community-based urban food system, in which resource circulation is connected with productive activities, community organization, and food security. The Sustainability Compass further provides a useful analytical perspective for understanding this multidimensionality because the outcomes of circularity cannot be adequately represented through environmental or economic indicators alone. The four dimensions—Nature, Economy, Well-being, and Society—demonstrate how resource recovery, economic activities, food-related benefits, institutional development, and community resilience can be analytically connected within a single community-based intervention.

Practically, the findings suggest that community-level CE initiatives require more than physical infrastructure or technological interventions. Capacity building, stakeholder collaboration, institutional recognition, and continuous knowledge exchange are important enabling conditions for translating circular-economy principles into local practice. For practitioners and local governments, this implies that urban farming initiatives using underutilized land can be designed not merely as food-production projects but as integrated platforms connecting waste management, livelihood development, local food production, and community resilience. However, these implications should be understood within the boundaries of the present case. As a qualitative single-case study, the findings provide contextual and analytical insights rather than evidence of causal program effectiveness or generalizable impacts across communities.

CONCLUSION

Based on the findings and discussion, this study concludes that the PERISAI NEGERI Program illustrates the potential for CE principles to be translated into community-level action through integrated urban farming and resource-looping activities. From a conceptual perspective, the integration of organic farming, freshwater fish farming, fishery-based MSME development, and waste-bank management demonstrates how previously underutilized land can be connected to a local circular production system. Rather than being limited to downstream waste management, the circular approach observed in this case connects resource recovery with food production and community economic activities.

From an implementation perspective, the findings indicate that capacity building, knowledge exchange, and multi-stakeholder collaboration were important enabling conditions for the development of the program. Training, benchmarking activities, infrastructure provision, and collaboration among community actors, local government,

corporate actors, and supporting organizations contributed to the development of community capacity and institutional arrangements for implementing circular activities. These findings suggest that community-level CE initiatives require not only technological interventions but also institutional and social mechanisms that enable communities to adopt and sustain circular practices.

The outcomes, interpreted through the Sustainability Compass, demonstrate multidimensional contributions across the Nature, Economy, Well-being, and Society dimensions. The Nature dimension was reflected in waste management, productive land utilization, and the use of renewable energy; the Economy dimension in the development of community business activities and revenue generation; the Well-being dimension in the availability of locally produced food and related community benefits; and the Society dimension in institutional strengthening, participation, and community resilience activities. Taken together, these findings indicate that CE initiatives can generate interconnected environmental, economic, social, and well-being outcomes at the community level.

Theoretically, this study contributes to the application of the CE concept by demonstrating how circularity can be examined beyond industrial and waste-management contexts and connected with community-based urban food systems. The Sustainability Compass provides an analytical lens for capturing these multidimensional outcomes and showing how environmental resource circulation, economic activities, community well-being, and social capacity are interconnected. Practically, the findings suggest that the development of community-based circular food initiatives can benefit from integrated capacity building, stakeholder collaboration, appropriate infrastructure, and institutional support. However, as a qualitative single-case study, this research does not establish causal effectiveness or generalizable impacts across other communities. Rather, it demonstrates the potential and observed contributions of the PERISAI NEGERI model within the specific context of Wanajaya Village. In this context, the model provides a locally grounded example of how CE practices may support food production, livelihood activities, and community resilience as part of broader efforts toward more sustainable local food systems.

LIMITATION

This study has several methodological limitations that provide opportunities for further research. First, the qualitative case-study approach enabled an in-depth understanding of the processes, experiences, institutional arrangements, and contextual mechanisms underlying the implementation of the CE program, but it did not allow the magnitude of changes or causal relationships between the intervention and food-security outcomes to be quantitatively estimated. Future studies could therefore complement qualitative inquiry with quantitative or mixed-method approaches to measure changes in food production, household economic conditions, food access, and other standardized food-security indicators. Second, the study analyzed program data covering January 2025 to May 2026, which provides a relatively limited temporal perspective for assessing the sustainability of circular-economy practices and their longer-term effects. Longitudinal studies covering a longer period are therefore needed to examine whether the observed environmental, economic, well-being, and social outcomes are sustained, strengthened, or change over time. Third, although the study involved representatives from four relevant stakeholder groups, the breadth of stakeholder perspectives remains limited. Future research could involve a wider range of actors, including individual beneficiary households, community groups, consumers, market actors, land or infrastructure managers, and government institutions at different levels, to capture a broader range of perspectives and interests. Finally, as this study focuses on a single community-based program in Wanajaya Village, its findings should be interpreted as context-specific rather

than statistically generalizable. Comparative multi-site studies could therefore be conducted to examine whether the CE mechanisms and Sustainability Compass outcomes identified in this case are applicable across different community, geographic, and institutional contexts.

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DECLARATION OF CONFLICTING INTERESTS

The authors have declared no potential conflicts of interest concerning the study, authorship, and/or publication of this article.

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