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Actor Interactions for Circular Economy Implementation in Rural–Urban Interfaces: Evidence from Malang Regency

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Abstract

This study aims to analyze the role of collaboration between actors in achieving sustainable development goals through the implementation of a circular economy in Karangwidoro Village, Malang Regency, East Java, Indonesia. Malang Regency was chosen because it has representative peri-urban characteristics, with rapid urbanization and coexistence between urban and rural elements. The data used are primary data through in-depth interviews and direct observation. Data collection was carried out from February to March 2025. This study uses MACTOR (Matrix of Alliances and Conflicts, Tactics, and Objectives for Risk Analysis) analysis to analyze among 9 main stakeholders, such as managers, partners, government officials, academics, and local communities. The research findings show that strong collaboration between central actors such as local governments, program managers, and academic institutions is critical to the successful implementation of a circular economy. However, challenges remain, especially with peripheral actors such as local communities, whose involvement tends to be sporadic and dependent on external factors. This study concludes that to ensure the sustainability of the program, collaboration between various existing actors is very important in achieving sustainable development goals through a circular economy, by utilizing synergies between government, society, private sector, and academics.

Keywords: Circular Economy, Sustainable Development, MACTORS, Collaboration

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INTRODUCTION

At present, sustainable development is one of the important agendas in the international world, especially since the Sustainable Development Goals (SDGs) were agreed upon by the United Nations in 2015. Sustainable

development is to improve the quality of human life without damaging the natural environment (Osipov, 2019). Sustainable development has become one of the most important issues in the current era of industrialization. Problems such as global warming due to greenhouse gas (GHG) emissions cause sea levels to rise due to melting polar ice caps.

This threatens coastal areas and small islands with increased flood risks. Furthermore, climate change has a direct impact on the agricultural sector. Rising temperatures and erratic rainfall patterns can lead to crop failure and decreased crop productivity. This has the potential to increase food prices and exacerbate hunger problems in many regions (Siagian, 2023).

The sustainable development agenda, which includes three main pillars of economic, social, and environmental, is the main foundation for realizing long-term welfare for communities in various sectors, including at the village level. Village development, as an integral part of sustainable development, aims to improve the quality of life of rural communities through improved infrastructure, local economy, and environmentally friendly natural resource management (Meida Rachmawati, 2024).

At the village level, development aims to improve various aspects of life, ranging from improving infrastructure that supports mobility and accessibility, to developing a more inclusive and competitive local economy (Priyaning Rahayu et al., 2022).

One area with complex challenges is the urban fringe. They are often transitional areas between urban and rural areas, where significant interactions between human activities and land use occur (Tian & Wang, 2020). Suburbs often experience rapid industrial and infrastructure development. This includes the development of industrial land and transportation infrastructure that supports economic growth and urbanization (Hasibuan et al., 2024). They often experience rapid social and economic change, including changes in land use and population demographics (Ji, 2018; Mou et al., 2024). This poses complex challenges for regional development in peri-urban areas.

Karangwidoro Village is a suburban area because it is located close to the center of Malang City and Batu City. The village is located in Dau Subdistrict, Malang Regency, East Java with a population of ± 6300 people. Around 60% of the village's population work as farmers and the rest as laborers, entrepreneurs, and civil servants. The main commodities are rice, corn, beans, vegetables, and oranges.

The implementation of circular economy in Karangwidoro Village involves two main approaches, namely urban farming by utilizing limited land to produce local food and organic waste management through composting and hydroponics. This reduces dependence on food imports, improves food security, and reduces waste.

Research by Gupta et al., (2019) shows that collaboration between stakeholders, such as governments, companies, and non-governmental organizations, is crucial for the success of the circular economy, especially in developing countries (Gebhardt et al., 2022; Mishra et al., 2021; Schultz et al., 2024). Arnold (2023) also emphasizes the importance of collaboration to create a beneficial symbiotic relationship, enabling the creation of a holistic and sustainable management system.

Research on actor collaboration in sustainable development and circular economy implementation in rural areas, especially in peri-

urban areas, is still limited, especially in formulating joint strategies to support the achievement of the Sustainable Development Goals (SDGs). Previous studies, such as the one conducted by Mukhlis et al. (2025), showed the importance of mapping the power and interests of actors in the success of collaborative programs, but have not comprehensively linked it to the implementation of circular economy and the integration of SDGs.

In addition, other studies such as that conducted by Yulianto & Mahmud (2024) focused more on the institutional context and did not address the challenges faced by rural communities. International studies also focus more on urban areas, while land transformation and consumption patterns in peri-urban areas, such as Karangwidoro, may affect the sustainable circulation of resources.

Therefore, this research aims to explore the collaborative role of local actors in integrating circular economy with SDGs in Karangwidoro Village, Malang Regency, focusing on the synergy between actors in driving the effectiveness of urban agriculture and waste management.

RESEARCH METHODS

This study employed a qualitative research design with a case study approach. The research was conducted at Tidar Villa Estate Housing, located on Jl. Villa Tidar Estate, Karang Tengah, Karangwidoro, Dau Subdistrict, Malang Regency, East Java. The data collected were primarily qualitative in nature, sourced directly through fieldwork. Primary data were obtained via in-depth interviews and direct observation. The interviews were carried out by visiting each of the nine selected respondents individually at their respective homes.

Data collection through interviews took place from February - March 2025. The key informants selected include individuals who have actively participated in the program or who have benefited from the program, such as managers, partners, government officials, academics, and the surrounding community.

Furthermore, data analysis using MACTOR (Matrix of Alliances and Conflicts: Tactics, Objectives, and Recommendations) analysis is used to analyze the behavior of actors in a system, focusing on strategies, alliances, and conflicts between actors participating in the development of a circular economy in Karangwidoro Village (Godet, 1991). The method is built on a table of actor strategies organized in the form of a matrix, where each diagonal cell lists the objectives of each actor, while the other cells include the means of action that one actor can use against another to achieve its objectives (Fauzi, 2019).

In this analysis, there are 6 steps that need to be done, including (Mukhlis et al., 2025): First, record each actor's plans, motivations, constraints, and modes of action (building an actor strategy table): The 9 actors were identified and categorized based on their roles and influence in the development of circular economy in Karangwidoro Village. Second, identifiy strategic issues and associated objectives: focuses on understanding the goals and objectives behind circular economy development.

This includes identifying the specific objectives that various stakeholders have in mind when supporting or participating in circular economy development initiatives. Third, Position each actor on each strategic issue and note convergences and divergences. Fourth, rank the objectives for each actor and assess

possible tactics. Fifth, Evaluate power relationships and formulate strategic recommendations for each actor. Sixth, Asking key questions about the future, i.e. formulating hypotheses regarding trends, events and discontinuities that will affect the evolution of power relations between actors.

Using MACTOR analysis can assist in strategic analysis by revealing the relative positions and strengths of actors on key issues, as well as identifying strategies and tactics employed (Josefsson et al., 2019; Kadaifci, 2024). Moreover, it can also facilitate collaborative decision-making by simulating convergence and divergence between actors, which is important in the framework of public-private partnerships (Ben-Daoud et al., 2023; Riadh, 2022). Thus, by diagnosing the balance of power and conflict between actors, it is ultimately possible to understand the power dynamics in further development or resource management projects.

RESULTS AND DISCUSSION

Karangwidoro Village is a village located in Dau Subdistrict, Malang Regency, East Java Province, Indonesia. Karangwidoro Village is located about 9 km from the Dau Sub-district office with an altitude of about 600 meters above sea level. The village covers an area of approximately 3.63 km² to 527.129 Ha (there are variations in the data, possibly different sources or measurements.

Its boundaries include Karangploso Subdistrict to the north, Wagir Subdistrict to the south, Kota Malang to the east, and Kota Batu to the west. Karangwidoro Village is divided into several hamlets, namely Karang Tengah, Karang Ampel, Karang Dara, Ndoro, and Citra Mas.

The population is around 5,900 to 6,300 people, with most of them working as farmers (around 60% to the majority). Apart from farmers, residents also work as laborers, self-employed, civil servants, and a small number as policemen, teachers, lecturers, doctors, and midwives. The main crops cultivated are rice, corn, beans, apples, oranges (including Pacitan oranges), and vegetables such as chili, tomatoes and beans. About 70% of the village land is used for agriculture, with about 46 ha of paddy fields and 298 ha of dry land. The village is known as a safe, clean and shady place with quite complete facilities from the government.

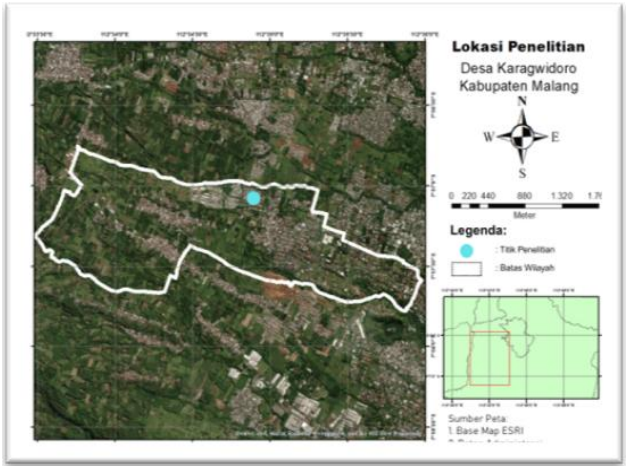

Figure 1. Research Location Map of Karangwidoro Village
Source: Base Map ESRI

In this study, MACTOR analysis was used to map the position and level of influence of the actors towards the development of a community-based circular economy in Karangwidoro Village. Based on qualitative data obtained through in-depth interviews, a number of key informants who have strategic roles in this program have been identified as shown in table 1.

From the results of in-depth interviews and direct observations with key informants, objectives were identified that were grouped

into economic, social and environmental dimensions (see table 2).

Within the MACTOR framework, the Matrix of Direct Influence (MDI) and the Matrix of Actors and Objectives (2MAO) function as essential foundational datasets for the analysis.

Table 1. Description of Key Informants

No	Code	Roles and Position	Role Description
1	PND	Manager	The main actor in the field; carrying out technical activities and bridging other actors.
2	ISN	Partner	Early advocate of ROTASI; played a role in the pioneering and training stages.
3	TON	Local Government	Structural support, appointing managers, fund facilitators and program direction.
4	TMS	Academics	Focus on research; not directly involved in the field.
5	MGS	Academics	Engage in research and service; provide conceptual input.
6	MAS1	Local Communities	Residents with early but inconsistent engagement.
7	MAS2	Local Communities	Residents who are passive and inactive in the program.
8	MAS3	Local Communities	Residents are quite active and are starting to get involved in activities.
9	MAS4	Local Communities	Citizens who lack involvement and contribution.

Source: Data processed, 2025

Matrix direct influence (MDI), or Actor X Actor, describes the interactions and direct influence between actors in the network, with each actor exerting influence through their actions and decisions. The mapping process begins by identifying relevant actors and analyzing influence relationships through interviews or surveys (Geissdoerfer et al., 2017).

For example, the influence of TON (Local Government) on PND (Manager) has a score of 3, which indicates a moderate influence in determining the direction of the circular economy program, with the government playing a key role in supporting policies and incentives (Geng et al., 2016). In addition, ISN (Partner) scored 2 in influencing MAS2 (Local Community), reflecting ISN (Partner) is role in encouraging community participation in formulating local policies.

Effective stakeholder engagement, which emphasizes collaboration between actors, is key in the circular economy (Onukwulu et al., 2025). ISN (Partners), although not directly involved in implementation, play a crucial role in the early stages, providing the foundation for the success of a sustainable circular economy (Fobbe &

Hilletofth, 2023). The Matrix of Actors and Objectives (2MAO) outlines the degree to which each actor supports, opposes, or remains neutral or indifferent toward a range of identified goals, while also reflecting how strongly those goals are prioritized by the actor. This matrix enables a deeper understanding of how actor preferences align with overarching program objectives, highlighting both their strategic focus and the likelihood of synergy or tension among stakeholders.

Table 2. Objective Identification

No	Category	Code	Description
1	Environment	L1	Increasing Awareness and Support for Sustainable Development
2	Environment	L2	Developing an Environmental Management Model Based on Local Needs and Potentials
3	Environment	L3	Organic Waste Reductio
4	Economy	E1	Increasing the Economic Value of Hydroponic and Compost Products
5	Economy	E2	Increasing Local Food Production through Hydroponics
6	Social	S1	Realizing a Community-Based Sustainable Environmental Management Model

Source: Data processed, 2025

The values in the table represent the likelihood of achieving the goal, with a value of -4 or 4 indicating a goal that is extremely important or harmful to the actor. For example, PND (Managers) show strong support for most objectives, with high scores such as "4", signifying strong alignment with strategic objectives (Iskandar & Ardianto, 2024).

Meanwhile, TMS (Academia) showed more varied attitudes, with some objectives receiving neutral or moderate support, signaling the need for further engagement to elicit their commitment to specific objectives (Pelling et al., 2015).

The Matrix of Direct and Indirect Influence (MDII) assesses the patterns of influence among actors, capturing both direct interactions and those mediated through other stakeholders. Unlike the MDI, MDII employs a distinct calculation scale but continues to reflect the intensity and relevance of actor interactions. This matrix generates two key indicators: the degree of influence (Ii), obtained by summing values across rows, and the degree of dependency (Di), derived from column totals. Higher scores on these metrics signify stronger influence relationships—whether exercised directly or through intermediaries.

MDI	PND	ISN	TON	TMS	MGS	MAS1	MAS2	MAS3	MAS4
PND	0	3	3	1	2	2	1	2	1
ISN	2	0	2	2	1	1	1	1	1
TON	4	3	0	1	2	2	1	2	1
TMS	1	3	1	0	1	1	1	1	1
MGS	2	1	3	1	0	2	1	2	1
MAS1	2	1	1	1	2	0	1	2	1
MAS2	1	2	1	1	1	2	0	1	1
MAS3	2	2	1	1	1	1	1	0	1
MAS4	1	1	2	1	1	2	1	1	0

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Figure 2. Matrix Direct Influence (MDI)
Source: Data processed, 2025

The five actors with the highest direct influence in the circular economy program in

Karangwidoro Village are PND (88), ISN (86), MAS3 (84), and TON (80). PND, as the manager, has the highest influence due to its very central role, not only in technical aspects such as hydroponic planting, maintenance, and harvesting, but also serves as a liaison for various stakeholders, including academics, partners, students, government, and local residents.

2MAO	L1	L2	L3	E1	E2	S1
PND	4	3	2	4	4	3
ISN	2	3	3	1	2	3
TON	3	3	2	2	3	3
TMS	2	1	1	1	1	2
MGS	3	3	3	2	2	2
MAS1	1	0	1	-1	2	0
MAS2	1	0	-1	1	1	0
MAS3	1	0	1	-1	0	0
MAS4	1	0	1	-1	0	1

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Figure 3. Matrix Actor Objective (2MAO)
Source: Data processed, 2025

When community participation began to decline, PND (Manager) consistently ran the activities independently, making her an irreplaceable key actor in maintaining the sustainability of the program. Her social exemplarity through commitment and dedication strengthens her influence (Ningrum et al., 2022).

ISN (Partner) received the second highest score due to its strategic role as the initial initiator who introduced the circular agriculture approach in utilizing vacant land and managing household waste in a sustainable manner. The partner not only designed activity models such as agroecology and hydroponics, but also provided technology and funding support through collaboration with ministries and higher education institutions. In addition, ISN (Partner) also strengthens community capacity through training and research-based internship programs (Permana et al., 2023; UNDP Indonesia, 2023)

MDII	PND	ISN	TON	TMS	MGS	MAS1	MAS2	MAS3	MAS4	ii
PND	14	13	12	9	11	11	8	12	8	84
ISN	10	11	10	9	10	10	8	10	8	75
TON	15	13	12	9	11	11	8	12	8	87
TMS	9	10	9	9	8	8	8	8	8	68
MGS	13	12	11	8	11	11	8	12	8	83
MAS1	11	10	10	8	10	10	8	11	8	76
MAS2	10	9	9	9	9	9	8	9	8	72
MAS3	10	10	10	9	9	9	8	9	8	73
MAS4	10	9	9	8	10	10	8	10	8	74
Di	88	86	80	69	78	79	64	84	64	692

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Figure 4. Matrix Direct and Indirect Influence (MDII)
Source: Data Processed, 2025

MAS3 (Local Community) plays a significant role although only a small number of residents are still actively involved in waste segregation for compost. They also act as social influencers and introduce new values such as productive waste segregation, maintaining the continuity of circular economy practices (Ceddia et al., 2024; Mukhlis et al., 2021).

The local government (TON), although not providing direct financial support, plays a crucial role in mobilizing the community to participate through meetings, community service, and counseling on waste management and hydroponics. TON (Local Government) also serves as a liaison between the community and other parties, and strengthens awareness about the importance of waste management and environmental sustainability (Arthur et al., 2023; Bolger & Doyon, 2019).

Actors with the highest indirect influence are TON (Local Government, 87), PND (Manager, 84), and MGS (Academia 1, 83). TON has a great influence in strengthening social cohesion and building trust among citizens, which encourages active participation in the circular economy (Martin et al., 2024).

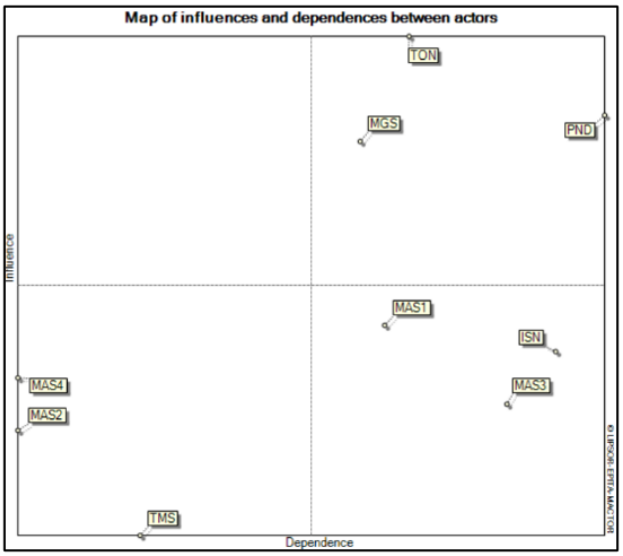

Figure 5. Map of Influences and Dependences between Actors
Source: Data Processed, 2025

PND (Managers), although not involved in high-level policy, have an important role in operationalizing the program and building social trust in the community (Permana et al., 2023). MGS (Academia), through research and extension, has a major indirect impact on policy and raising community awareness (Pereira et al., 2024).

Moderate indirect influence is shared by MAS1 (Local Community 1, 76), ISN (ROTASI Partner, 75), and MAS4 (Local Community 4, 74). MAS1 is involved in daily activities such as composting and hydroponics, but its consistency depends on external factors (Rimantho et al., 2023). ISN (partners) play a role in program coordination and facilitation, but their influence is limited by resources and collaboration (Tenera & Rosas, 2019). MAS4 (Local Community) also play a role in collective activities, but their contribution is limited by access and manager support.

Actors with the lowest indirect influence are MAS3 (Local Community 3, 73), MAS2 (Local Community 2, 72), and TMS (Academia 2, 68). MAS3 (Local Community) and MAS2 (Local Community) have sporadic involvement in waste management and hydroponic activities, so their influence on program sustainability is limited (Maria, 2022). TMS (Academia), as academics, play a role in research and extension, but their influence in the field is limited due to lack of direct interaction with the community (Smit et al., 2024).

The influence and dependency map between actors illustrates the position of actors in terms of their influence and dependency in the circular economy program in Villa Tidar Estate. Actors such as TON (Local Government), PND (Manager), and MGS (Academia) are in Quadrant II, showing great influence but also dependency on other actors (Bianchi et al., 2023). TON (Local Government) has an important role in policy support and encouraging citizen participation, while PND (Managers) manage field operations, and MGS (Academics) contribute through ideas and concept coaching (Freedman, 2017).

MAS4 (Local Community), MAS2 (Local Community), and TMS (Academic) are in Quadrant III, with low influence and dependency, as their involvement in practical activities is limited (Smit et al., 2024). MAS1, MAS3, and ISN are in Quadrant IV, with low influence but high dependency, relying on other

actors to run the program (Bonnyventure, 2022). There are no actors in Quadrant I, which is ideal for community-based program management because it has high influence and low dependency (Tuladhar et al., 2024).

The absence of actors in this position indicates that community structures are still evolving and program sustainability relies heavily on collaboration between actors and strengthening institutional capacity (Abreu & Ceglia, 2018). Efforts are needed to build actor independence and encourage active participation so that the program can run more solidly and thoroughly (Schauppenlehner-Kloyber, 2017).

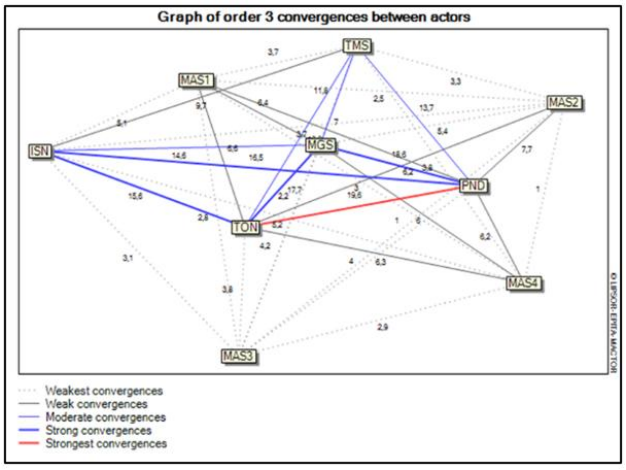

Figure 6. Map Convergences between Actors
Source: Data Processed, 2025

Figure 6 illustrates the convergence between actors in circular economy management in Karangwidoro Village, with the closer the actors, the stronger their convergence. Strong convergence is seen between TON (Local Government) and PND (Manager), which reflects the alignment of goals in waste management and community behavior change.

TON (Local Government) focuses on mindset change and citizen mobilization, while PND (Manager) manages technical aspects, such as organic waste processing and hydroponics, which show tangible results for the community (Geissdoerfer et al., 2017; Kirchherr et al., 2017; Reynolds et al., 2020). The blue line shows the strong convergence between TON (Local Government), ISN (Partners), PND (Managers) and MGS (Academia), leading to a change in community mindset and active citizen support.

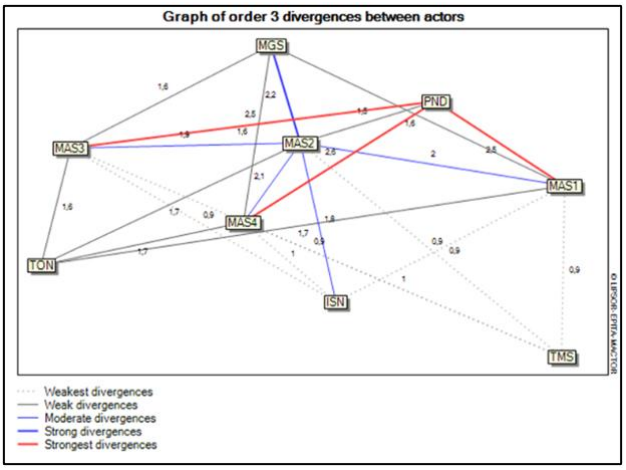

Figure 7. Map Divergences between Actor
Source: Data Processed, 2025

ISN (Partners) provides training and practical support, while MGS (Academia) plays a role in formulating research-based policies (Bocken et al., 2016; Linder et al., 2017). On the other hand, weaker convergence is seen between peripheral actors such as MAS1 (Local Community) to MAS4 (Local Community) and central actors, who show limited engagement and are influenced by external factors, such as environmental awareness and local support (Adhikari et al., 2016; Millar et al., 2019).

The low engagement of peripheral actors demonstrates the importance of participatory approaches and community-based education to strengthen their influence and ensure program sustainability (Hopkinson et al., 2018; Velenturf

& Purnell, 2021). Based on the MACTOR analysis, a strong divergence was observed between MAS1 (Local Community), MAS3 (Local Community), and MAS4 (Local Community) with PND (Manager), indicating a mismatch between the expectations of peripheral actors and the policies of PND (Manager) in managing the circular economy in Karangwidoro Village.

Community involvement is limited and influenced by external factors, such as low environmental awareness and lack of understanding of circular economy benefits, while PND (Manager) focus on waste management and structured hydroponics (Mies & Gold, 2021; Ritzén & Sandström, 2017). To overcome this divergence, a participatory and communicative approach is needed, which not only focuses on technical aspects, but also on shared understanding and social incentives (Geissdoerfer et al., 2017).

Moderate divergence between MAS2 (Local Community) and MGS (Academia) reflects the gap between academic knowledge and the practical needs of communities, while weak divergence is seen between TMS (Academia) and Local Community, indicating the limited impact of theory without direct engagement (Bocken et al., 2016; Franco, 2017; Ranta et al., 2018).

Weak divergence also exists between TON (local government) and communities, demonstrating the importance of external factors such as awareness and social support in increasing citizen participation (Kirchherr et al., 2017). Overall, while not leading to open conflict, these divergences reduce the effectiveness of circular economy programs, and require more inclusive and community-based communication strategies (Mies & Gold ., 2021).

CONCLUSION

This study examined the role of stakeholder collaboration in implementing a village-level circular economy program, using the MACTOR methodology to map how key actors (local government, program managers, community partners, and academics) influence each other and align their objectives.

Key findings indicate distinct power dynamics among these actors: the local government assumes a pivotal role by leveraging its authority and community mobilization capacity; program managers translate policy into practice on the ground; and community partners and academics contribute through training and knowledge support.

The MACTOR analysis identified strong alliances between the local government and program managers—reflecting aligned goals in waste management and community behavior change—while also exposing divergences between program leaders and less-engaged community members due to uneven participation and misaligned priorities.

These insights highlight the initiative's alignment with Sustainable Development Goals (notably SDG 11 on sustainable communities, SDG 12 on responsible consumption and production, and SDG 17 on partnerships) by advancing environmental sustainability, community empowerment, and multi-stakeholder governance.

Based on these results, strategic recommendations emphasize leveraging actor power dynamics. Highly influential actors such as the local government should enact supportive policies (for example, a village circular economy regulation) and incentive schemes to institutionalize and sustain the program.

Meanwhile, actors with lower influence—particularly local community members—need to be empowered through education, capacity-building, and inclusion in decision-making to increase their participation and reduce dependency on key players. Establishing a multi-stakeholder coordination forum is also advised to maintain alignment of goals and collective ownership among all participants. Although this study is context-specific, future research could compare governance strategies across different rural settings, or assess how varying actor configurations affect the durability of community-based sustainability programs.

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