Organic Waste Management Strategy To Create Sustainable Circular Economy Using Swot And Qspm Model

Rahayu[1*], Putra[2], Pujo[3]

[1,2,3] Biomanagement Study Program, School of Life Sciences and Technology,
Institut Teknologi Bandung. Jl. Ganesha 10 Bandung 40132, Indonesia
[*] Corresponding Author:
Email: rickyselametr@gmail.com

Abstract.

Organic waste management is crucial for sustainable climate change adaptation and mitigation. It supports a circular economy by recycling and repurposing waste, considering the entire product life cycle. This includes initiatives to recycle and repurpose organic waste as valuable resources, promoting a circular economy approach. The aim of the current study is to determine the best strategy for managing organic waste that can support a sustainable circular economy. SWOT analysis is a strategic planning tool based on strengths, weaknesses, opportunities, and threats. The QSPM assesses the attractiveness of alternative strategies for managing organic waste, evaluating external and internal factors that influence the organization. Further research is needed to promote sustainable circular economy principles.This research used the SWOT and QSPM Model to determine the best strategy for managing organic waste that can support a sustainable circular economy. The process involves analyzing internal and external factors of an organization, using the SWOT matrix to identify alternative strategies for programs or activities, and then using QSPM analysis to determine the sequence of these strategies and determine the best to lowest-value strategy outcomes, ensuring data input and decision-making. This study has been carried out in Garut, West Java, Indonesia in 2023. The study analyzes the progress of organic waste processing in Garut Regency using the SWOT-QSPM approach. The results provide insights into the organic waste management strategy for a sustainable circular economy, highlighting the importance of recycling organic waste into new products and supporting society's economy. The circular economy principle can be applied to the processing of organic waste by using BSF, a biological agent that can produce livestock feed and plant fertilizer, reducing the amount of organic waste sent to landfills. The strategies discovered can guide community programs, empowering those without fixed incomes to manage waste. The cultivation of BSF can be integrated with the farm, aiming to reduce poverty and unemployment rates, convert unused land into a community-managed waste management center, aiming to enhance production and income, educate and support the well-being of the community. The best practices for handling organic waste in Garut Regency to promote a sustainable circular economy have been determined by the SWOT-QSPM model. The chosen strategy prioritized 3 main aspects out of 7 alternative strategies : (1) Recruiting society members to manage organic waste processing centers as a routine activity and additional income through processing and cultivation programs; (2) Increasing productivity and scaling up the processing of organic waste to obtain diverse products with higher economic value; (3) Providing direct training and education on organic waste processing to the society to demonstrate the economic value that processed organic waste can generate.

Keywords: *Circular Economy; Management Strategy; Organic Waste; Sustainability; SWOT-QSPM; and Usefulness.*

I. INTRODUCTION

Sustainability has always depended on addressing environmental issues, and in the twenty-first century, these issues have gained significant attention [9]. One of the issues that is currently rising is related to sustainable management. Which includes one of the objectives of sustainable waste management principles and supported by a management aspect that focuses on the economic circular based on community-based programmes. Duodu [10] stated that the issue of climate change and the extent and severity of its effects have been the subject of concern for the international community, including Indonesia. In order to support this, the Indonesian government actively develops policies, legislation, strategies, and programs for climate change adaptation and mitigation, as well as monitoring and evaluating the control of climate change impacts. Global issues also interest in developing technology that utilize renewable energy sources, or "green energy," has grown in recent decades due to the advantages it offers in terms of the environment and the economy [2].Waste encompasses any undesired solid, liquid, or gaseous material. Inadequately handled waste can harm humans, animals, plants, and the environment. Approximately half of all generated waste is organic. Therefore, effective management of organic waste can significantly diminish pollution resulting from improper waste disposal practices [3]. In managing organic waste, it is crucial for achieving a circular economy as it can be recycled into a source of new product or fertilizer.

Organic waste can be efficiently converted into biomass rich in proteins and fats, which can use as animal feed [21]. Furthermore, organic waste can be used to create bio-based fertilizers, which can originate from urban environments or the food and biomedical industries [4]. Organic waste materials like crop

residues and cattle manure are also used as cheap organic fertilizers because they are rich in micro and macro nutrients, which improve plant growth, soil fertility, and crop production [28]. The idea of a circular economy focuses on reducing waste by taking into account the complete product life cycle, from production through to the recovery of resources. Specifically concerning organic waste, it involves initiatives to recycle and repurpose organic waste as valuable resources. Furthermore, this concept could serve as a framework for a circular economy, where waste generated by industries is minimized and transformed into valuable resources instead of being discarded outright [17][18]. Circular economy definition encompasses various levels of activity like micro (involving products, companies, or consumers), meso (in eco-industrial parks), and macro (in cities, regions, etc.). At the macro level, there are ample opportunities to implement strategies within the Circular Economy framework. Municipal Solid Waste (MSW) and industrial waste management systems at this scale offer opportunities to advance the Circular Economy agenda [1].The demand for animal products has increased due to factors such as world population growth, urbanization, and welfare [11] [12].

However, because of the large ecological footprint associated with the production of meat and dairy, the addition of more animal-based products poses a significant challenge to the sustainability of the global food production system [15][34][16]. Thus, the establishment of profitable and sustainable livestock and fishery production systems as well as the guarantee of food security—particularly in developing nations—require access to inexpensive and creative feed [37]. Because of their capacity to break down and value various organic wastes, protein-rich edible insects have recently gained recognition as cutting-edge protein substitutes [24][36][35]. Therefore, this research was conducted to address the waste issue in Garut Regency, specially in an administrative village Sukajaya and Padamulya, West Java Province, Indonesia enabling the implementation of the circular economy concept to support society well-being. The community-based organic waste processing activity that has been undertaken is by exploiting biological agents through the the larvae of the black soldier fly (BSF) bioconversion process that produces the main product as fresh maggot and by-products of fertilizer "kasgot" or in other terms BSF insect dirt that is useful for fertilization. Insects are also abundant in fatty acids, calories, and minerals [32][13][24]. Hermetia illucens L., the larvae of the black soldier fly (BSFL), has been found to be a viable feed item for aquaculture, pigs, and poultry [20][19][9][37]. Originating in the Americas, black soldier fly (BSF) populations can be found worldwide in most tropical and temperate locations [32]. About 35 to 49% of the BSFL's total dry weight is made up of crude protein, while the remaining 29 to 35% is made up of fat, and their amino acid profile is comparable to fishmeal's [29][6][33][14]. Besides, another by-product of this research is by integrating against poultry cattle to produce eggs.

Even though it is found naturally in chicken, pig, and cow dung, BSFL have been successfully raised on a variety of organic waste streams, including coffee grounds, fish viscera, vegetable remnants, catering trash, and urban municipal organic waste [23][6]. Furthermore, BSF breeding has just been achieved on an industrial scale to lessen the significant volumes of garbage these facilities produce [22][30].Therefore, this research was conducted to address the waste issue in Garut Regency, specially in an administrative village Sukajaya and Padamulya, West Java Province, Indonesia enabling the implementation of the circular economy concept to support society well-being. Previous research has been conducted by Paes et al. [25] to conduct a comprehensive literature review and analysis to assess the current status and use SWOT analysis method of organic waste management using circular economy principles. The SWOT analysis is a method that revolves around four key elements: strengths, weaknesses, opportunities, and threats. It was developed for strategic planning analysis and its outcomes are applied in strategic management. Further research is needed regarding strategies for managing organic waste that promote sustainable circular economy principles. The strategy for managing organic waste is crucial for achieving goals in the circular economy. The QSPM is designed to assess the relative attractiveness of feasible alternative strategies by evaluating key external and internal factors that influence or impact the organization [26].Therefore, the aim of the current study is to determine the best strategy for managing organic waste that can support a sustainable circular economy. This study has been carried out in Garut, West Java, Indonesia in 2023.

II. METHODS

Analysis strategic planning technique is employed to determine the best strategy for managing organic waste that can support a sustainable circular economy comprising three stages. The process involves analyzing internal and external factors of an organization or group, using the SWOT matrix to identify alternative strategies, and then making decisions using the Quantitative Strategic Planning Matrix (QSPM) to determine the sequence of alternative strategies and determine the best to lowest-value strategy outcomes. This data-driven approach helps in decision-making and strategic planning. This method is highly appropriate for determining the best strategy based on recent research on renewable resources by Pazouki [26] which is a valuable tool for formulating strategies based on internal and external evaluations and SWOT analysis, defining the significance of factors, trends, roles, and data among strategic alternatives.

Involves data input by analyzing internal and external factors

Internal factor evaluation (IFE) matrix is a strategic tool utilized to assess a firm's internal environment, highlighting its strengths and weaknesses and External Factor Evaluation (EFE) matrix as a strategic tool used to analyze a company's external environment and identify the existing opportunities and threats [26]. The development strategy for organic waste management in Garut Regency, West Java, Indonesia, involves determining internal and external factors. Internal factors evaluation assesses strengths and weaknesses, while external factors evaluation evaluates opportunities and threats. Each factor is assigned weights ranging from 0.0 to 1.0, with a rating value magnitude determined based on the program implementer's response on a scale of 1-5. Scores 1-5 indicate weak response, while scores 2-5 indicate average performance. The program's success is evaluated based on the program's performance. After multiplying the weight by the score, the attractiveness of each factor can be determined. If the sum of all effective factors is less than 3, it indicates that weaknesses outweigh strengths. Conversely, sums greater than 3 demonstrate that strengths dominate over weaknesses.

Analysis alternative strategy using the SWOT matrix

A SWOT analysis outlines factors that contribute to achieving management organic waste objectives and identifies obstacles that need to be managed or minimized to attain desired outcomes [26]. **Fig 1** indicates the process of SWOT. Modifying from Pazouki [26] that SO strategies (aggressive strategies) leverage strengths to capitalize on opportunities. ST strategies (diversification) utilize strengths to mitigate threats. WO strategies (growth strategies) capitalize on opportunities to address weaknesses, and WT strategies (defensive strategies) mitigate vulnerabilities and avoid threats. **Table 1** indicates the SWOT analysis matrix.

Table 1. SWOT analysis matrix modified from Pazouki [26]

	Strength	Weakness
Opportunities	How do the strengths organic waste program take advantage of these opportunities?	How do the weaknesses organic waste program that prevent from taking advantage of the opportunity?
Threats	How do organic waste program strengths to reduce the impact of threats?	How do the weaknesses organic waste program will make these threats a reality?

Encompasses decision-making using Quantitative Strategic Planning Matrix (QSPM) analysis

In determining prioritization in the management strategy of organic waste processing activities, the QSPM analysis matrix can be utilized [26]. If a tested strategy achieves the highest total score in the QSPM matrix, it is considered that there most suitable strategy for implementation. For scoring, internal and external factors which have crucial roles in organic waste processing will be evaluated through interviews with program stakeholders. Scores ranging from 1 to 5 will be assigned, as previously conducted. If a factor does not have a significant role in the strategy selection process, it will not receive a score. The QSPM matrix utilizes weight values and Attractive Score (AS) values. From these values, the Total Attractive Score (TAS) is calculated. Strategies with the highest TAS values become the primary choice for priority strategy, while those with the lowest TAS values are considered last priority [7] [26].

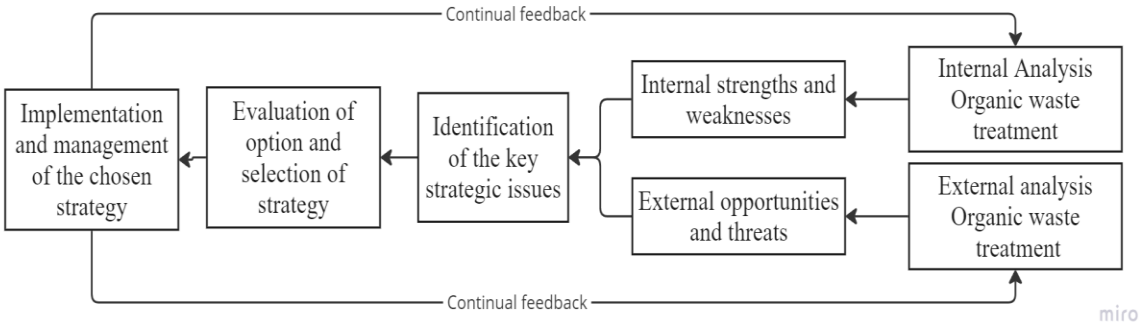

Fig 1. The Process of SWOT organic waste modified from Pazouki [26]

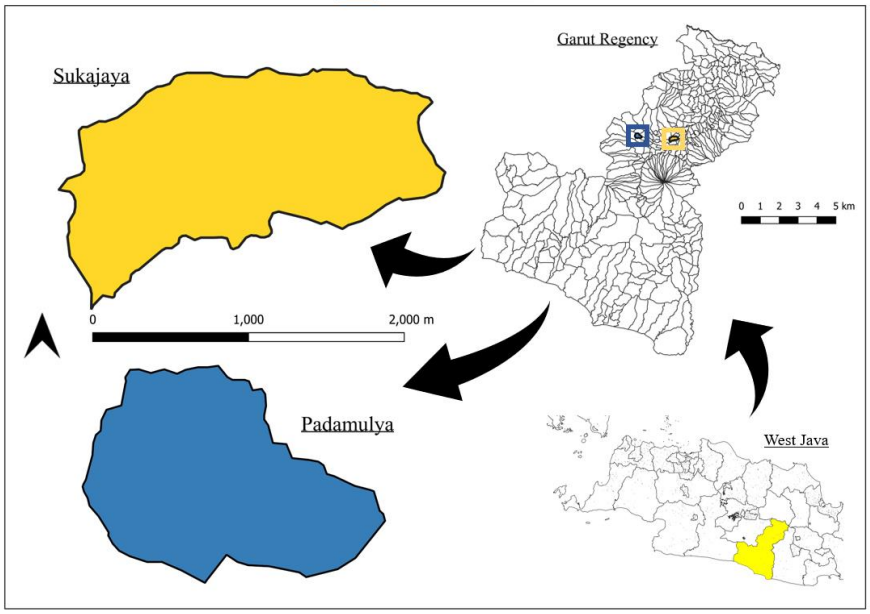

Fig 2. Geographical location of the study area in Garut Regency, West Java Indonesia ; (1) Administrative village Sukajaya (2) Administrative village Padamulya

III. RESULT AND DISCUSSION

In a process of analyzing the progress of organic waste processing that has been carried out in two research locations in Garut Regency specially in an administrative village Sukajaya and Padamulya, West Java Province, Indonesia **(Fig 2.)**, the following are the results obtained from the analysis stages of the SWOT-QSPM approach [26] that will be used to determine the organic waste management strategy in realizing a sustainable circular economy in Garut Regency. Several factors have been analyzed related to the availability of data that has been obtained from observations in the field. In addition to the economic aspects that refer to the sustainability of the circular economy, other aspects such as environmental and social aspects were explored in depth in an interview.

The two locations have similar factors that have been considered in determining the scoring along with discussions with several key informants in the field. The determination of internal and external factors is the first step in determining the formulation of a strategy for the development of organic waste processing program activities that have been carried out in Garut Regency. From the results of observations and interviews obtained Based on the identification of activities, conclusions were obtained for 7 cases that were found as strengths, 5 cases as weaknesses, 6 cases as weaknesses and 5 cases as threats owned or caused by organic waste management that had been carried out. Furthermore, an IFE and external factors (EFE) is carried out by scoring each SWOT that has been obtained. The results of the assessment of internal and external factors are presented in **Table 2**.

Table 2. Internal factor evaluation matrix

STRENGHTS		Weight (0.0-1.0)	Score (1-5)	Weighted score
S1	Easy to obtain organic waste at program implementation sites	0.1471	5	0.735
S2	High society awareness and enthusiasm for the importance of waste sorting	0.0882	3	0.265
S3	Environmental conditions at program implementation sites are suitable and supported by the local society	0.1176	4	0.471
S4	Several locations can be used for installing poultry or fish farms and directly using maggots as feed	0.0588	2	0.118
S5	Outputs from waste processing (maggot eggs, fresh maggots, dried maggots, and poultry/fish harvests) have high market value	0.0588	2	0.118
S6	Some people are accustomed to waste processing and also engage in livestock farming as daily side activities	0.0294	1	0.029
S7	The society is involved in social bonds through traditional or social organizations youth associations, empowering family welfare society, mosque managers society and support to collaboration	0.0588	2	0.118
WEAKNESS				
W1	Bioconversion of organic waste using *Hermetia illucens* (Black Soldier Fly) is still new information and needs to be learned by the society.	0.1471	5	0.735
W2	Human resource performance and increased participation of people are still insufficient.	0.1176	4	0.471
W3	Lack of access to market facilities for raw materials and procurement/supply of supporting materials for the program still requires assistance.	0.0882	3	0.265
W4	Society members have busy schedules and primary jobs, thus they are unable to fully participate actively.	0.0882	3	0.265
	Total Internal Factor	1		3.588

Table 3. External factor evaluation matrix

OPPORTUNITY		Weight (0.0-1.0)	Score (1-5)	Weighted score
O1	Participating creates a market for farmers and livestock breeders in supplying affordable feed needs, thereby strengthening the economy in program organic waste.	0.0968	3	0.290
O2	Creating job opportunities for low-educated people.	0.1290	4	0.516
O3	The resulting products can be consumed to improve people's nutrition and produced locally.	0.0323	1	0.032
O4	Creating new positive activities for the people that involve productive activities to confront crises food in the future through society resilience.	0.1290	4	0.516
O5	Potentially push the municipal government programs related to environmental pollution, poverty alleviation, and improving nutrition (stunting).	0.0323	1	0.032
O6	The program organic waste can serve as examples for various groups, including individuals, communities/organizations, schools, and other related institutions.	0.1613	5	0.806
THREATS				
T1	There are several other people's interests that do not support and disrupt the program's progress.	0.0645	2	0.129
T2	Competitors who feel disadvantaged by the program's implementation.	0.0645	2	0.129
T3	Environmental conditions that hinder the program	0.1290	4	0.516

	(weather, pests, and diseases) which disrupt program productivity.			
T4	Inconsistent momentum and society enthusiasm to ensure consistency in carrying out organic waste activities.	0.0323	1	0.032
T5	Difficulty in finding offtakers will hinder the final process of the resulting productivity.	0.1290	4	0.516
	Total External factor	1		3.516

Based on the results of the weighting of the IFE and EFE matrices (**Table 2**. and **Table 3**.), an IFE score of 3.588 and an EFE score of 3.516 were obtained with details presented in **Table 4.** The results show that the IFE value has a greater value compared to the EFE value or in other words in the running of sustainable organic waste processing, it is indicated that internal factors are more influential than external factors or opportunities and threats that come.

Table 4. IFEM and EFEM Total Weight

Factors	Weight	Sum
Strengths	0.559	1
Weaknesses	0.441	
Opportunities	0.581	1
Threats	0.419	

Furthermore, weight aggregation is carried out by focusing on positive and negative aspects (the value of strengths and opportunities has a greater value than weaknesses and threats) so that they are grouped based on positive and negative status (**Table 5.**) which later by giving weights based on internal and external factors a strong strategy or strategy tendency is obtained through the SO strategy approach with the greatest attraction shown by Figure 3. in the selection of strategies that are more suitable and consistent with the problems faced in the management of organic waste processing that have been carried out in the field. According to Pikton & Wright [27] in Pazouki [26] explained that strategies with set values form an offensive so that the factors of strength and opportunity can be adapted so that the selection of strategies can be focused on the SO aspect.

Table 5. IFEM and EFEM Results with positive and negative approach

Status	Factors	Weight	Sum
Positive	Strengths	0.559	1.581
	Opportunities	0.581	
Negative	Weaknesses	0.441	0.861
	Threats	0.419	

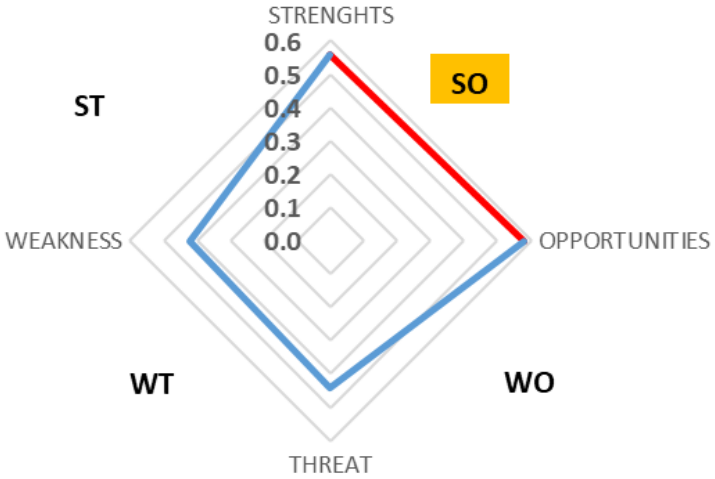

Fig 3. Strategy management organic waste based on IFEM and EFEM

Based on the analysis of the SO strategy that will be prioritized (**Fig. 3**) in determining alternative strategies, 6 alternative strategies have been obtained that have been discussed in the implementation of organic waste management in Garut Regency. The results of the formulation of alternative strategies are presented in **Table 6.**

Table 6. SWOT matrix : Derivation of key management strategies organic waste in Garut Regency

		Strength (S)	
		S1	Easy to obtain organic waste at program implementation sites
		S2	High society awareness and enthusiasm for the importance of waste sorting
		S3	Environmental conditions at program implementation sites are suitable and supported by the local society
		S4	Several locations can be used for installing poultry or fish farms and directly using maggots as feed
		S5	Outputs from waste processing (maggot eggs, fresh maggots, dried maggots, and poultry/fish harvests) have high market value
		S6	Some people are accustomed to waste processing and also engage in livestock farming as daily side activities
		S7	The society is involved in social bonds through traditional or social organizations youth associations, empowering family welfare society, mosque managers society and support to collaboration
Opportunities (O)			Strategies on the basis of strength and opportunities factors (SO)
O1	Participating creates a market for farmers and livestock breeders in supplying affordable feed needs, thereby strengthening the economy in program organic waste.	SO1	Providing direct training and education on organic waste processing to the society to demonstrate the economic value that processed organic waste can generate.
O2	Creating job opportunities for low-educated people.	SO2	Recruiting society members to manage organic waste processing centers as a routine activity and additional income through processing and cultivation programs.
O3	The resulting products can be consumed to improve people nutrition and produced locally.	SO3	Increasing productivity and scaling up the processing of organic waste to obtain diverse products with higher economic value.
O4	Creating new positive activities for the people that involve productive activities to confronting crises food in the future through society resilience.	SO4	Socializing the concept of integrating organic waste processing with livestock as a single system to produce high-nutrient harvests, collaborating with empowering family welfare society or other communities as a platform for socialization.
O5	Potentially push the municipal government programs related to environmental pollution, poverty alleviation, and improving nutrition (stunting).	SO5	Introducing education, training, and direct practice related to organic waste processing with monitoring throughout the process until it becomes productive and self-sustaining.
		S06	Collaborating with communities to attract public interest in waste processing activities and regular society gatherings such as meetings with youth associations, empowering family welfare society, mosque managers society, or collaboration with government agencies that have a purpose focused on the environment.
O6	The program organic waste can serve as examples for various groups, including individuals, communities/organizations, schools, and other related institutions.	SO7	Utilizing the Learning Center as an education and information hub providing facilities to assist communities/institutions interested in learning and independently applying organic waste processing in their respective environments.

Based on the results of the SWOT analysis that has been made, in determining the priority of assessing the strategy in the development of organic waste processing activities in Garut Regency, it is carried out using the QSPM matrix (**Fig.4**). The results of the QSPM matrix test are calculated.The results of the strategy assessment based on the QSPM analysis can be seen in **Table 7.**

Table 7. Priorities of the organic waste management executive strategies

Strategy attractiveness score	Strategy	Description of strategy
3.96	SO2	Recruiting society members to manage organic waste processing centers as a routine activity and additional income through processing and cultivation programs.
3.72	SO3	Increasing productivity and scaling up the processing of organic waste to obtain diverse products with higher economic value.
2.81	SO1	Providing direct training and education on organic waste processing to the society to demonstrate the economic value that processed organic waste can generate.

2.55	SO6	Collaborating with communities to attract public interest in waste processing activities and regular society gatherings such as meetings with youth associations, empowering family welfare society, mosque managers society, or collaboration with government agencies that have a purpose focused on the environment.
2.54	SO4	Socializing the concept of integrating organic waste processing with livestock as a single system to produce high-nutrient harvests, collaborating with empowering family welfare society or other communities as a platform for socialization.
1.74	SO5	Introducing education, training, and direct practice related to organic waste processing with monitoring throughout the process until it becomes productive and sustain.
1.57	SO7	Utilizing the Learning Center as an education and information hub providing facilities to assist communities/institutions interested in learning and independently applying organic waste processing in their respective environments.

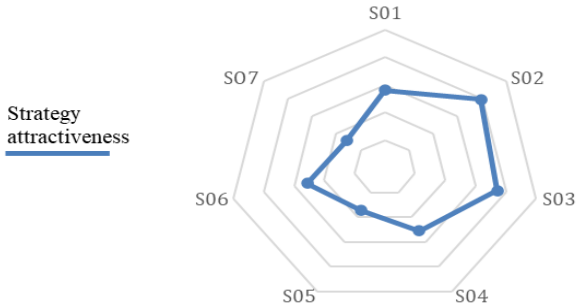

Fig 4. SWOT Analysis result : Strategy attractiveness

Based on the results of the QSPM matrix test, the best alternative strategies that can be carried out for organic waste management in Garut Regency to determine the goal of realizing a sustainable circular economy. Based on 7 alternative strategies that have been formulated, there are 3 main priorities of the strategy that will be chosen : (1) Recruiting society members to manage organic waste processing centers as a routine activity and additional income through processing and cultivation programs; (2) Increasing productivity and scaling up the processing of organic waste to obtain diverse products with higher economic value ; (3) Providing direct training and education on organic waste processing to the society to demonstrate the economic value that processed organic waste can generate. The strategies discovered can serve as a foundation for planning the implementation of programs. The first step implementation can be carried out in the community with a scheme empower communities that do not have a fixed income and are willing to commit themselves to management of waste with intensive accounting based on income or revenue obtained from the results of organic waste processing through the cultivation of *Hermetia illucens* (BSF). That also integrated with the farm to reduce the poverty rate or unemployment rate in the society. Then, implementation of the second program is to make use of unused land into a site of waste management center managed by the community in the hope of providing more optimum production and increased income so as to support the well-being of the people.

Last, implementation of the third program is to provide education and support in the technical application of organic waste treatment so that the community can better practice with methods of efficient and profitable organic waste management in terms of benefits to the economy and the environment around.The principle of circular economy in the processing of organic waste can use the biological agent of *Hermetia illucens* (BSF) so it can produce products that can be used as livestock feed and also other products as fertilizer for plants. The use of black soldier fly (BSF) (H*ermetia illucens*) larvae as a sustainable source of protein for animal feed has grown significantly [31] . It is crucial to increase food production without using more land, and understanding sustainable feed substitutes that are affordable for circular agricultural systems helps enhance sustainability [5]. This is economically beneficial and also reduces the waste organic sent to the final disposal site. For an extended period, scholars worldwide have suggested employing the larvae of the black soldier fly (*Hermetia illucens*) (Diptera: *Stratiomyidae*) as a possible method for breaking down organic wastes, like food scraps, in order to redirect the materials from the restricted landfills [8].

IV. CONCLUSION

From 7 alternative strategies that have been formulated, there are 3 main priorities of the strategy that will be chosen : (1) Recruiting society members to manage organic waste processing centers as a routine activity and additional income through processing and cultivation programs; (2) Increasing productivity and scaling up the processing of organic waste to obtain diverse products with higher economic value ; (3) Providing direct training and education on organic waste processing to the society to demonstrate the economic value that processed organic waste can generate. The strategies discovered can serve as a foundation for planning the implementation of programs. The first step involves empowering communities with no fixed income to manage waste through intensive accounting based on income from organic waste processing. This can help reduce poverty and unemployment rates. The second program involves using unused land for waste management centers, aiming to provide optimum production and increased income for the community's well-being. The third program provides education and support in the technical application of organic waste treatment, enabling the community to practice efficient and profitable methods for economic and environmental benefits.

V. ACKNOWLEDGMENTS

R.S. Rahayu, the corresponding author, played a pivotal role in the research by collecting observational data and conducting interviews, interpreting the results, and preparing the manuscript. Dr. R.E. Putra and Dr. Pujo provided invaluable assistance in revising the manuscript and offering guidance throughout the research process. The authors extend their sincere gratitude to F.I. Firdaus for his significant contribution in mapping the research locations. The experimental work was conducted in Sukajaya and Padamulya, West Java, Indonesia, with the collaborative support of the author and Institut Teknologi Bandung (ITB). This research would not have been possible without the comprehensive support and resources provided by these esteemed institutions and individuals.

REFERENCES

[1] Abad, V. (2019). Promoting circular economy in the surroundings of an organic fraction of municipal solid waste anaerobic digestion treatment plant: Biogas production impact and economic factors. **Bioresource Technology**, *283*, 10–17.

[2] Akande, O. M., & Olorunnisola, A. O. (2018). Potential of briquetting as a waste-management option for handling market-generated vegetable waste in Port Harcourt, Nigeria. **Recycling**, *3*(2).

[3] Ayilara, M. S. (2020). Waste management through composting: Challenges and potentials. **Sustainability (Switzerland)**, *12*(11).

[4] Case, S. D. C. (2019). Nitrogen and phosphorus release from organic wastes and suitability as bio-based fertilizers in a circular economy. **Environmental Technology (United Kingdom)**, *40*(6), 701–715.Chia SY, Tanga CM, van Loon JJ, Dicke M. Insects for sustainable animal feed: inclusive business models involving smallholder farmers. **Curr Opin Env Sust**. 2019;41:23–30.

[5] Dabbou, S., Gai, F., Biasato, I., Capucchio, M. T., Biasibetti, E., Dezzutto, D., ... & Schiavone, A. (2018). Black soldier fly defatted meal as a dietary protein source for broiler chickens: Effects on growth performance, blood traits, gut morphology and histological features. ***Journal of animal science and biotechnology***, 9, 1-10.

[6] David, . F.R.,. (1999). *Strategic management concept and cases (7th Edition)*. Prentice Hall.

[7] Diener, S., Zurbrügg, C., & Tockner, K. (2015). Bioaccumulation of heavy metals in the black soldier fly, Hermetia illucens and effects on its life cycle. ***Journal of insects as food and feed***, 1(4), 261-270.

[8] Dörper, A., Veldkamp, T., & Dicke, M. (2021). Use of black soldier fly and house fly in feed to promote sustainable poultry production. ***Journal of Insects as Food and Feed***, 7(5), 761-780.

[9] Duodu, M. G. (2022). Waste management through bioremediation technology: An eco-friendly and sustainable solution. **Relationship Between Microbes and the Environment for Sustainable Ecosystem Services, Volume 2: Microbial Mitigation of Waste for Sustainable Ecosystem Services**, *5*, 205–234.

[10] FAO (2009). How to Feed the World in 2050. Rome: FAO.

[11] UN (2014). **World Urbanization Prospects**, the 2014 Revision: Highlights. Available online at:

[12] Finke, M. D. (2013). Complete nutrient content of four species of feeder insects. **Zoo biology**, 32(1), 27-36.

[13] Gasco, L., Dabbou, S., Trocino, A., Xiccato, G., Capucchio, M. T., Biasato, I., & Gai, F. (2019). Effect of dietary supplementation with insect fats on growth performance, digestive efficiency and health of rabbits. ***Journal of Animal Science and Biotechnology***, 10, 1-9.

[14] Gerber, P. J., Steinfeld, H., Henderson, B., Mottet,A.,Opio,C.,Dijkman,J.,et al.(2013).**Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities**.Available online at:

[15] Kim, B. F., Santo, R. E., Scatterday, A. P., Fry, J. P., Synk, C. M., Cebron, S. R., ... & Nachman, K. E. (2020). Country-specific dietary shifts to mitigate climate and water crises. **Global environmental change**, 62, 101926.

[16] Leong, S. Y. (2021). A circular economy framework based on organic wastes upcycling for biodiesel production from hermetia illucens. **Engineering Journal**, *25*(2), 223–234.

[17] Leong, S. Y., Kutty, S. R. M., Malakahmad, A., & Tan, C. K. (2016). Feasibility study of biodiesel production using lipids of Hermetia illucens larva fed with organic waste. **Waste Management**, 47, 84-90.\Lock, E. J., Biancarosa, I., & Gasco, L. (2018). Insects as raw materials in compound feed for aquaculture. **Edible insects in sustainable food systems**, 263-276.

[18] Makkar, H. P., Tran, G., Heuzé, V., & Ankers, P. (2014). State-of-the-art on use of insects as animal feed. **Animal feed science and technology**, 197, 1-33.

[19] Mertenat, A. (2019). Black Soldier Fly biowaste treatment – Assessment of global warming potential. **Waste Management**, *84*, 173–181.

[20] Miranda, C. D., Cammack, J. A., & Tomberlin, J. K. (2020). Mass production of the black soldier fly, Hermetia illucens (L.) (Diptera: Stratiomyidae) reared on three manure types. **Animals**, 10(7), 1243.

[21] Nguyen, T. T., Tomberlin, J. K., & Vanlaerhoven, S. (2015). Ability of black soldier fly (Diptera: Stratiomyidae) larvae to recycle food waste. **Environmental entomology**, 44(2), 406-410.

[22] Nowak, V., Persijn, D., Rittenschober, D., & Charrondiere, U. R. (2016). Review of food composition data for edible insects. **Food chemistry**, 193, 39-46.Paes, L. A. B. (2019). Organic solid waste management in a circular economy perspective – A systematic review and SWOT analysis. ***Journal of Cleaner Production***, *239*.

[23] Pazouki, M. (2017). Strategic management in urban environment using SWOT and QSPM model. **Global *Journal of Environmental Science and Management,*** *3*(2), 207–216.

[24] Pikton, W. D., & Wright, S. (1998). What's SWOT in strategies analysis, Strategic Change . **Strategic Change,** *7(2)*, 101–109.

[25] Raza, S. T. (2019). Vermicomposting by Eisenia fetida is a Sustainable and Eco-Friendly Technology for Better Nutrient Recovery and Organic Waste Management in Upland Areas of China. ***Pakistan Journal of Zoology***, *51*(3), 1027–1034.

[26] Renna, M., Schiavone, A., Gai, F., Dabbou, S., Lussiana, C., Malfatto, V., ... & Gasco, L. (2017). Evaluation of the suitability of a partially defatted black soldier fly (Hermetia illucens L.) larvae meal as ingredient for rainbow trout (Oncorhynchus mykiss Walbaum) diets. ***Journal of animal science and biotechnology***, 8, 1-13.

[27] Scala, A., Cammack, J. A., Salvia, R., Scieuzo, C., Franco, A., Bufo, S. A., & Falabella, P. (2020). Rearing substrate impacts growth and macronutrient composition of Hermetia illucens (L.)(Diptera: Stratiomyidae) larvae produced at an industrial scale. **Scientific reports,** 10(1), 19448.

[28] Seyedalmoosavi, M. M., Mielenz, M., Veldkamp, T., Daş, G., & Metges, C. C. (2022). Growth efficiency, intestinal biology, and nutrient utilization and requirements of black soldier fly (Hermetia illucens) larvae compared to monogastric livestock species: a review. ***Journal of Animal Science and Biotechnology***,13(1), 31.

[29] Sheppard, D. C., Newton, G. L., Thompson, S. A., & Savage, S. (1994). A value added manure management system using the black soldier fly. **Bioresource technology**, 50(3), 275-279.

[30] Spranghers, T., Michiels, J., Vrancx, J., Ovyn, A., Eeckhout, M., De Clercq, P., & De Smet, S. (2018). Gut antimicrobial effects and nutritional value of black soldier fly (Hermetia illucens L.) prepupae for weaned piglets. **Animal Feed Science and Technology**, 235, 33-42.

[31] Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., ... & Willett, W. (2018). Options for keeping the food system within environmental limits. **Nature**, 562(7728), 519-525.Surendra, K. C., Tomberlin, J. K., van Huis, A., Cammack, J. A., Heckmann, L. H. L., & Khanal, S. K. (2020). Rethinking organic wastes bioconversion: Evaluating the potential of the black soldier fly (Hermetia illucens (L.))(Diptera: Stratiomyidae)(BSF). **Waste Management**, 117, 58-80.

[32] Van Huis, A., & Tomberlin, J. K. (2017). The potential of insects as food and feed. **In Insects as food and feed: from production to consumption** (pp. 25-59). Wageningen Academic Publishers.

[33] Veldkamp, T., & Vernooij, A. G. (2021). Use of insect products in pig diets. ***Journal of Insects as Food and Feed***, 7(5), 781-793.