Jurnal Perlindungan Tanaman Indonesia, Vol. 27, No. 1, 2023: 41–50
DOI: 10.22146/jpti.72071
Available online at http://jurnal.ugm.ac.id/jpti
ISSN 1410-1637 (print), ISSN 2548-4788 (online)

Research Article

Sustainability and Strategy of Vegetable Crops Enterprises Based on Integrated Pest Management (Case Study in Mekarsaluyu Village, Cimenyan Subdistrict, Bandung Regency)

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Received January 13, 2022; revised February 3, 2022; accepted July 28, 2023

ABSTRACT

Crop enterprises in Mekarsaluyu Village, Cimenyan Subdistrict, Bandung Regency have contributed to the economic activities of the local community. However, current vegetable crop enterprises are not suitable according to sustainable agriculture concepts and face several obstacles in its sustainability, such as the availability of water, access to capital, farmers' concern for environmental sustainability, as well as the role of farmer groups and farmer group association. Integrated pest management (IPM) is a sustainable agricultural production subsystem that can help control pests on vegetable crops, with the use of pesticides as a last resort. This study aims to assess the sustainability status and formulate a farming management strategy based on IPM. The sustainability status was analyzed using the uses the RAP-IPM (Rapid Appraisal for Integrated Pest Management) method which is a modification of the RAPFISH (Rapid Appraisal for Fisheries), and strategy was analyzed using the SWOT and the QSPM method. Respondents were determined by purposive sampling. The sustainability status of vegetable farming based on IPM tends to be quite sustainable with a sustainability index value of 58.23% and the prioritized management strategies are (1) strengthening farmer institutions including farmer groups and farmer groups associations, marketing institutions, and business groups agriculture in meeting the need for vegetable demand in the market; (2) development of environmentally friendly integrated pest control technology and preparation of effective and efficient alternative production facilities including land management, labor requirements, planting area in accordance with factual conditions in the field; and (3) strengthening agricultural financing institutions to meet the needs of agricultural production facilities and infrastructure.

Keywords: crop enterprises; integrated pest management; strategy; sustainability status

INTRODUCTION

The potential for the economic development of vegetable crops is shown by the growth of agricultural gross domestic product (GDP) of 2.59% *year-on-year* (yoy) in the fourth quarter of 2020. The increase in demand for fruit and vegetables caused horticultural commodity production to grow by 7.85% (Ministry of Agriculture, 2021). Vegetable commodities have a strategic role especially in rural areas as an income sources, absorb labor, source of agro-industry raw materials, potential export commodities which are a source of state foreign exchange reserves, and open non-agricultural sector markets, especially upstream industries (Pujiharto, 2011). In 2020, the total export value of shallots, garlic, large chilies, cayenne peppers, potatoes, tomatoes, and carrots reached $49 million (Statistics Indonesia, 2021). It is projected that the trend of vegetable products consumption for the 2018–2022 period will increase with an average growth rate of 1.05% (Alfaena, 2018).

Several criteria that can be used as a reference for sustainable agricultural development involve ecological, economic, social, technological, and institutional aspects (Khasan *et al*., 2015). Mekarsaluyu is a village located in Bandung Regency where most of the livelihood comes from the agricultural sector. The farming system is carried out by intercropping due to limited arable land area. One of the problems related to the sustainability of vegetable farming in Mekarsaluyu Village is the decrease in area of land used for agricultural (Statistics Indonesia Bandung Regency, 2021). The continuous use of chemical inputs which decreases soil quality becomes an ecological problem. Farming culture with continuous chemical inputs socially shows that the level of farmers' concern for environmental sustainability is still low. Likewise, the implementation of IPM is still low (Saida, 2011). The current access to capital is also deemed inadequate. Production cost allocations are generally concentrated on spending for chemical fertilizers and pesticides. The cost of chemical pesticides can be reduced by applying IPM technology, a sustainable agricultural production subsystem that can help control pests on vegetable crops, with the use of pesticides being the last option (Effendi, 2009; Prabaningrum & Moekasan, 2011; Sudiono *et al.,* 2017). Therefore, it is necessary to have and implement a sustainable vegetable farming management strategy on IPM. This study aims to analyze the sustainability status and formulate a sustainable vegetable farming management strategy based on IPM in Mekarsaluyu Village, Bandung Regency.

MATERIALS AND METHODS

Study Site

The research was conducted in Mekarsaluyu Village, Cimenyan Subdistrict, Bandung Regency, West Java Province, Indonesia (Figure 1) from September to December 2021. This area is located at 700–1,200 masl and is one of the centers for producing vege-table horticultural crops in Bandung Regency. Mekarsaluyu Village is heavily dominated by vegetable horticultural production which has become the major source of income for local farmers. Annual average rainfall in this village is 1500 mm with an average temperature of 26–29°C (Mekarsaluyu Village Information System, 2021).

Data Collection

Primary data were collected using a questionnaire survey. The survey was conducted with 25 farmers engaged in horticultural crops and members of the Farmers Group in Mekarsaluyu Village. The farmers were selected by purposive sampling on farmers that are directly involved in horticultural vegetables production, members of a farmer group, grows vegetable crops, such as shallots, red chilies, potatoes, tomatoes and cabbage, and mainstay farmers. The main crops cultivated by the farmers were shallots, red chilies, potatoes, tomatoes, and cabbage. The data were also gathered through field observation. Experts in IPM were 2 representatives of the Department of Food Crops and Horticulture of West Java Province, 2 representatives from Vegetable Plant Research Center, 2 representatives from Agricultural Extension Center Cimenyan Subdistrict, farmer group leader, and academia. Secondary data were obtained from existing literature.

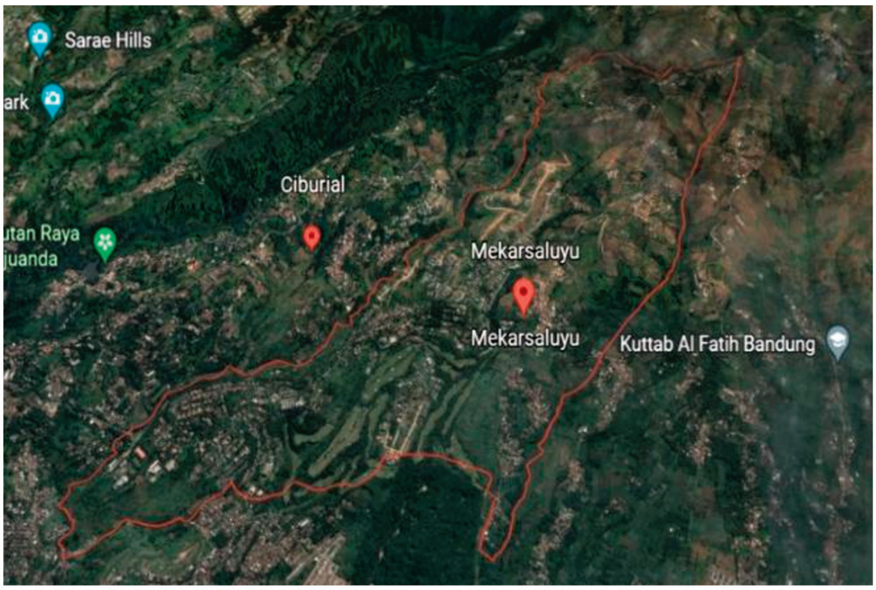


Figure 1. Study area at Mekarsaluyu Village, Cimenyan Subdistrict, Bandung Regency, West Java, Indonesia

Data Analysis

To identify vegetable farming sustainability based on IPM, the data were analyzed using Multidimensional Scaling (MDS) with RAP-IPM (Rapid Appraisal for Integrated Pest Management) method which is a modification of the RAPFISH (Rapid Appraisal for Fisheries) program developed by the Fisheries Center, the University of British Columbia since 1998 to assess the status of fisheries sustainability (Kavanagh, 2001; Pitcher *et al.,* 2013). The ordination technique was performed based on the five dimensions of sustainability including ecological, economic, social, institutional, and technological dimensions with a set of 10–17 attributes from each dimension. The position of sustainability status will be based on the category in the range of 0–100% (Table 1). In the RAP-IPM approach, most influential attributes were determined by the *Laverage Analysis* method and predict errors in the process of analysis using the Monte Carlo method (Pitcher *et al.,* 2013). Internal and external factors was identified using the IFE and EFE matrix, the formulation of farming management strategies used the SWOT matrix and priority strategies for farming management was determined using the QSPM (*Quantitative Strategic Planning Matrix*) method.

Table 1. The Sustainability Index Scales Category (Rosmiati *et al.,* 2020)

Index Scale (%)	Information
00 – 24.99	Unsustainable
25 – 49.99	Less sustainable
50 – 79.99	Quite sustainable
80 – 100.00	Very sustainable

RESULTS AND DISCUSSION

Ecological Sustainability

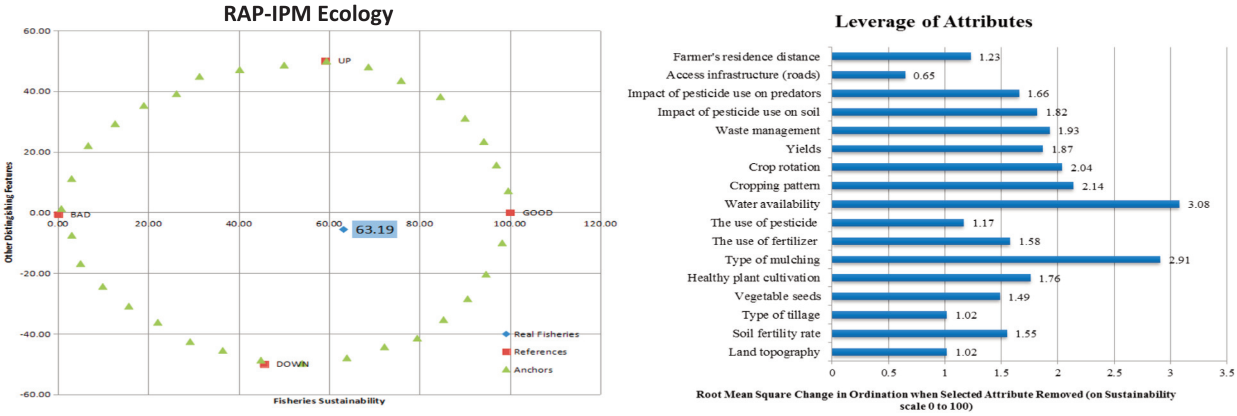
RAP-IPM analysis showed that the sustainability index of the ecological dimension was 63.19% which was categorized as quite sustainable (Figure 2a). Based on leverage analysis, there were two dominant attributes affecting the index which were water availability and type of mulching (Figure 2b). Unavailability of water in the dry season was an indicator of environmental damage, drying up of springs around agricultural land. Mekarsaluyu Village located in the highlands should also work as a water catchment area. However, this can only take place if the vegetation that grows on the land are annual plants with deep roots and able to absorb air into the soil while holding the soil from surface erosion (Narulita *et al.*, 2008). Forest land-use change into agricultural land and buildings in Mekarsaluyu Village, without adequate conservation measures, may cause various environmental damage that will later have an impact on the farming. Silver plastic mulch vegetable crops productions could provide benefits including: (1) protection of main crop against weed; (2) reflects light to under foliation to interrupt pests; (3) maintains soil moisture; (4) minimizes fertilizer run-off by rain; (5) reduces weed control cost; (6) avoidance of nutrients loss; and (7) prevents erosion of the beds (Baker *et al.,* 2020).

Economic Sustainability

The sustainability status of the economic dimension was less sustainable at 46.45% (Figure 3a). The most sensitive attributes identified were capital access and agricultural equipment price (Figure 3b). Agricultural development is largely determined by land, labor potential, water, and local rural economic base (Surya, 2013). Procurement of more varied sources of capital, such groups, the private sector, or the government can be a solution to farmers' capital constraints. Capital is the main obstacle making it one of the main strategic plans of the ministry of agriculture (Ministry of Agriculture, 2015). Capital institutions such as cooperatives, banks or other financial institutions are needed to support vegetable horticulture farming in Mekarsaluyu Village. Most farmers find the price of agricultural equipment expensive (hand tractors, water suction machines, and other maintenance equipment). Some farmer groups have received hand tractors as government accommodation, but the positive impact has not been experienced equally by all group members. There were several group members who did not get the opportunity to use the hand tractor because they had to wait their turn. This limitation of agricultural tools resulted in delays in the planting schedule. Delay in planting risks transmitting pests/diseases from the surrounding mature plants.

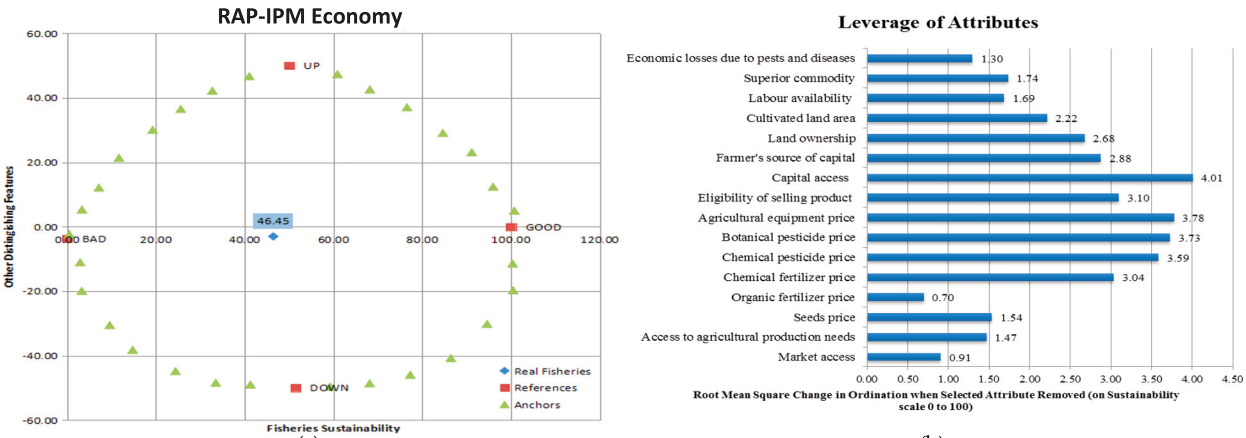
Social Sustainability

The sustainability index of the social dimension was the highest among other dimensions, although



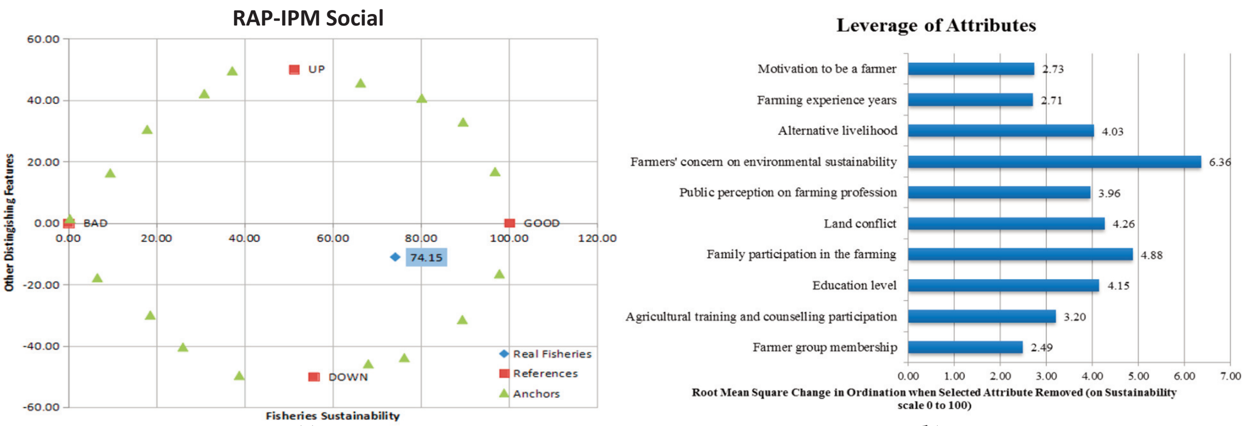
(a) (b)

Figure 2. Sustainability index (a) and leverage analysis results (b) of the ecological dimension



(a) (b)

Figure 3. Sustainability index (a) and leverage analysis results (b) of the economic dimension



(a) (b)

Figure 4. Sustainability index (a) and leverage analysis results (b) of the social dimension

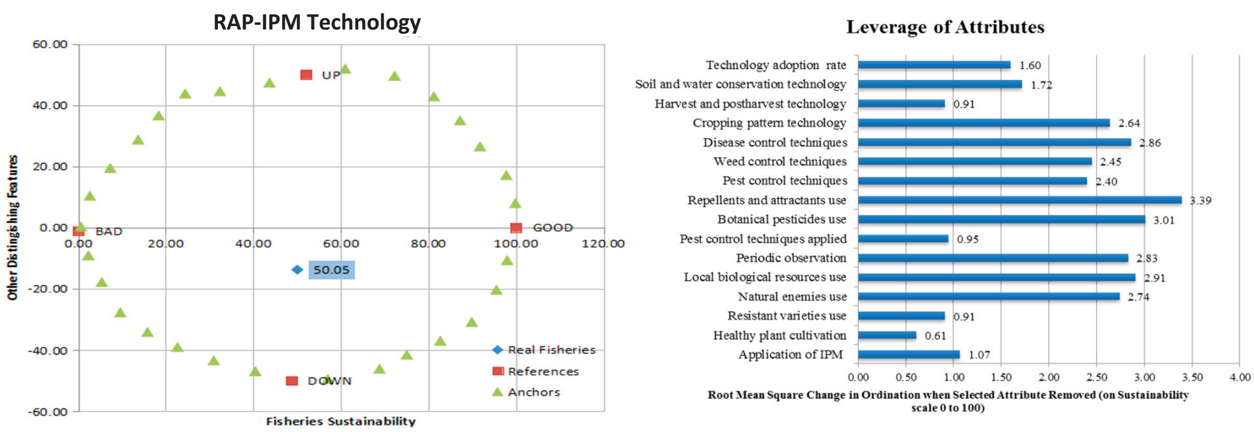
it was still categorized as quite sustainable (74.15%) (Figure 4a). Farmers' concern for environmental sustainability and family participation in farming were two attributes analyzed that had the greatest influenceon the index (Figure 4b). The majority of farmers knew that continuous chemical inputs could degrade soil quality, but forced to ignore it because of economic constraints. Farmers' perception of environmental-friendly technology in vegetable crop production requires higher costs, longer harvest times, and yield less than using chemical inputs. However, previous studies showed that environmental-friendly pest control in Ciamis Regency in extreme conditions was able to reduce the use of pesticides by 73.33% with a yield of 15.46 tons/ha, reduce soil temperature by 0.89°C and CO_2 emissions by 38.76%, (Setiawati & Sumarni, 2012) and further increase the population of soil arthropods and predators *Menochilus sexmaculatus* by 87.18% in the chili ecosystem (Setiawati *et al.*, 2014). This shows that information about environmental-friendly technology is still not conveyed properly. Therefore, the role of the community is essential. Agricultural extension workers is also important to solve this problem. The participation of families in farming such as wives and children were low. The fair distribution of labor among family members is an indicator of high human productivity on agricultural land (Untari *et al.,* 2007). Young labor were more interested in working in the service and industrial sectors, especially in urban areas. The sustainability of vegetable horticulture farming in Mekarsaluyu Village still required young labor. Support from all parties is needed so that young labor remain interested in the farming because the main factor of agriculture as a source of income for the community is not only determined by the availability of natural resources but also determined by the potential of the labor (Surya, 2013).

Technological Sustainability

Technology was also a dimension categorized as quite sustainable, with an index value of 50.05% (Figure 5a). The dominant attributes that affected the index were the use of repellents, attractants, and botanical pesticides (Figure 5b). The use of repellent and attractant plants has been reported to be able to control pests below the economic threshold and was safe for the environment (Baker *et al.*, 2020). Nevertheless, vegetable farmers in Mekarsaluyu Village do not use repellent and attractant plants due to results not fulfilling farmers' expectations who are already accustomed to the results of chemical control. The next sensitive attribute is the use of botanical pesticides. Botanical pesticides are biodegradable, do not pollute the environment, are relatively safe for humans, and have low pest resistance. However, it has several obstacles in the application, including impracticality, slow pest efficacy, high cost, does not kill the target directly, low resistance to sunlight, and must be applied repeatedly, thus farmers prefer chemical pesticides.

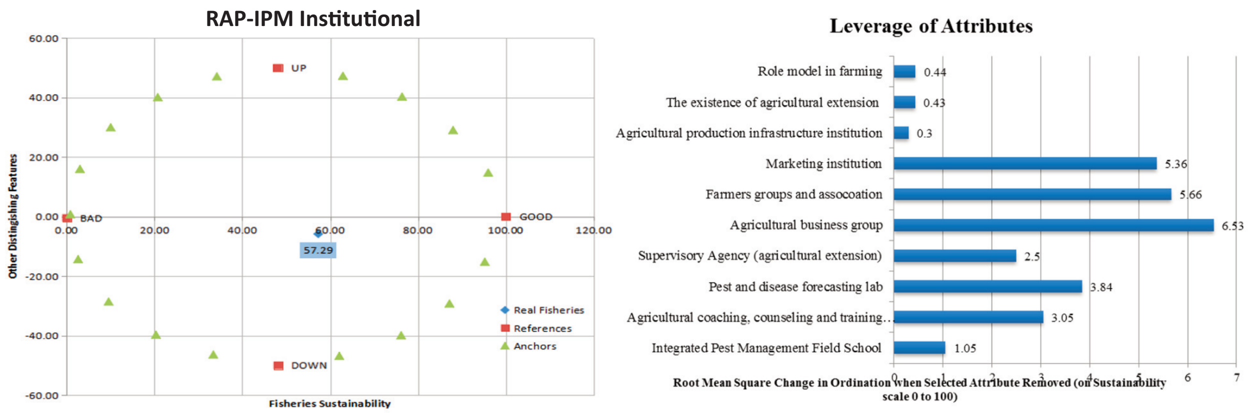
Institutional Sustainability

The result of RAP-IPM showed that the value of the sustainability index for the institutional dimension was 57.29% (quite sustainable) (Figure 6a). Based on Figure 6b, the most sensitive attributes identified were agricultural business group, farmers groups, and association. The agricultural business group was the attribute with the highest sensitivity value, which was 6.53%. Agricultural business groups are a medium for farmers to establish cooperation with other parties or institutions. The second sensitive attribute was the farmer group and association, which its existence have not been able to impact farmers evenly. Farmer groups and association existence were only temporary, especially when there was accommodation from the government. Farmer group association as an institutional asset of the Ministry of Agriculture is expected to be more useful



(a) (b)

Figure 5. Sustainability index (a) and leverage analysis results (b) of the technological dimension



(a) (b)

Figure 6. Sustainability index (a) and leverage analysis results (b) of the institutional dimension

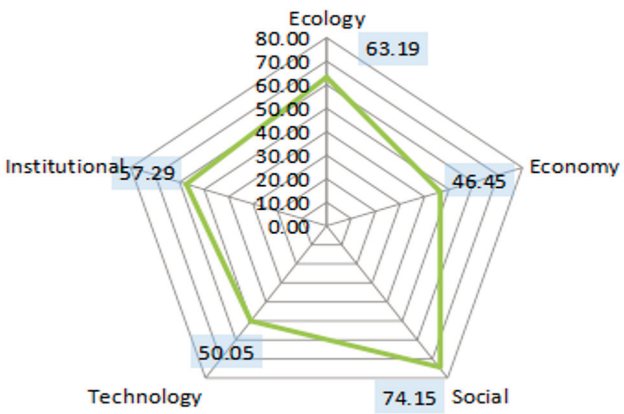


Figure 7. Kite diagram of sustainability index of five dimensions

Table 2. The Validation of RAP-IPM Analysis

Dimension	Sustainability Index (%)	R^2	Stress
Ecology	63.19	0.95	0.14
Economy	46.45	0.95	0.12
Social	74.15	0.92	0.15
Technology	50.05	0.96	0.13
Institution	57.29	0.95	0.13

as per the Minister of Agriculture Regulation number 273/Kpts/OT.160/4/2007, carry out economic functions in processing business units, production input business units, marketing business units, and microfinance business units (Samekto, 2011). Intense and strong assistance is needed for these institutional so their existence is truly beneficial for farmers.

Sustainability Index of Five Dimensions

The index of sustainability of five dimensions is presented in the kite diagram (Figure 7). The figure depicts that vegetable farming based on IPM in Mekarsaluyu Village was categorized as quite sustainable based on five dimensions (ecology, economy, social, technology, and institutional). The social dimension had the highest index of sustainability at 74.15%, while the economic dimension has the lowest index at 46.45%. The results of RAP-IPM validation are shown in Table 2. The table illustrates that the stress value of each dimension is below 20% and the value of R^2 is close to 1. This validation indicates that the RAP-IPM model is sufficiently suitable for sustainability analysis.

Table 3. The Quantitative Strategic Planning Matrix (QSPM)

S-O Strategies	Weight	AS	TAS	*Rank*
1. Develop regulations and operational standardization of IPM implementation in terms of (1) healthy plant cultivation, (2) preservation of natural enemies, (4) integrated ecosystem monitoring, and (5) realizing active farmers as IPM experts	0.033	3.8	0.124	8
2. Increasing the role of extension workers (agricultural extension field and plant pest control officer) through regular monitoring and evaluation of all farmer groups to produce vegetable products with good quality	0.043	3.8	0.163	7
W-O Strategies				
1. Optimizing the role of agricultural extension workers through socialization of environmental sustainability by reducing the use of chemical pesticides and starting to implement IPM technology to produce vegetable products of good quality in terms of health	0.061	3.4	0.205	5
2. Strengthening farmer institutions including farmer groups and *Gapoktan*, marketing institutions, and agricultural business groups to meet vegetables demands in the market	0.093	3.6	0.339	1
S-T Strategies				
1. Strengthening agricultural financing institutions to meet the needs of vegetable farming facilities and infrastructure	0.074	3.8	0.277	3
2. Agricultural intensification to increase the quantity and quality of environmentally sound vegetable products on limited land so that they can compete with vegetable-producing areas with better land suitability	0.049	3.8	0.183	6
W-T Strategies				
1. Development of environmentally friendly integrated pest control-based control technology and preparation of effective and efficient alternative production facilities including land management, labor requirements, planting area according to factual conditions in the field	0.080	3.6	0.290	2
2. Improving farming practices with chemical fertilizers and pesticides and starting to implement IPM technology to overcoming pests and plant diseases to reduce expenditure on pesticides	0.070	3.8	0.262	4

Note: AS = attractive score, TAS = total attractive score

Farm Management Strategy

Vegetable farming management strategy based on IPM was carried out by making an IFE and EFE matrix. The IFE Matrix (Internal Factor Evaluation) is a strategic formulation tool used to summarize and evaluate the main strengths and weaknesses in functional business areas, and also forms the basis for identifying and evaluating relationships between these areas (Santoso, 2013). The internal factor with the highest weight that becomes a strength in maintaining the sustainability of vegetable horticulture farming based on IPM in Mekarsaluyu Village is the existence of a farmer group with a weight of 0.054. While the highest weight of internal factors that become a weakness was the role of farmer groups and farmer group association not evenly distributed with a weight of 0.122. On external factors, the highest weight was the opportunity category in maintaining the sustainability of vegetable farming based on IPM was the government's commitment to improve the vegetable farmers welfare with a weight of 0.093. While the highest weight of external factors that pose a threat in maintaining the sustainability of vegetable farming based on integrated pest control was inadequate access to capital with a weight of 0.120. Internal and external factors were used to develop a SWOT matrix for further formulation of alternative strategies using QSPM. There were 8 alternative strategies with 2 S-O strategies, 2 W-O strategies, 2 S-T strategies, and 2 W-T strategies (Table 3).

Three strategies were obtained that later became the main priority, namely strengthening farmer institutions including farmer groups and farmer group association, marketing institutions, and agricultural business groups in meeting the need for vegetable demands in the market with a TAS value of 0.339. The second priority strategy is the development of environmentally friendly integrated pest control-based control technology and the preparation of effective and efficient alternative production facilities including land management, labor requirements, planting area according to factual conditions in the field with a TAS value of 0.290. The third priority strategy is strengthening agricultural financing institutions to meet the needs of agricultural production facilities and infrastructure with a TAS value of 0.277.

CONCLUSION

Vegetable farming sustainability status based on IPM in Mekarsaluyu Village, Bandung Regency was quite sustainable with combined sustainability index of 58.23% based on the in five dimensions categories. The sustainability index for ecological dimension (63.19%), social dimension (74.15%), technological dimension (50.05%), and institutional dimension (57.29%) were categorized as quite sustainable, while the economic (46.45%) dimension was considered less sustainable.

The main priority strategies that can be carried out vegetable farming sustainability management based on IPM in Mekarsaluyu Village, Bandung Regency include: (1) strengthening farmer institutions including farmer groups and farmer group associations, marketing institutions, and agricultural business groups to meet vegetables demand in the market (0.339); (2) development of environmentally friendly IPM based control technology and preparation of effective and efficient alternative production facilities including land management, labor requirements, planting area according to factual conditions in the field (0.290); and (3) strengthening agricultural financing institutions to meet the needs of agricultural production facilities and infrastructure (0.277).

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