

## **Sustainability Assessment of Integrated Pest Management Rice Farms to Enchange Food Security in Kediri District**

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### **ABSTRACT**

As one of the regions with the potential to become a national food production center, Kediri District in East Java has initiated the implementation of an organic farming system. To ensure the long-term viability of this agricultural system, it is essential to assess its level of sustainability. The objective of this study is to conduct a sustainability analysis to ascertain the status of sustainability and optimization strategies for IPM rice farming in the district. The research was conducted in Kediri District, with samples of Sugihwaras Village and Pandantoyo Village, involving a total of 100 respondents. These respondents were then interviewed to measure the six dimensions and 51 attributes used in the study. The data was analyzed using Multidimensional Scaling (MDS) RAP-IPM, and a prospective analysis was subsequently conducted. The results indicate that the sustainability scores for each dimension are as follows: ecology (83.29), technology (78.21), policy (81.31), and institutional (79.31), which suggest a very sustainable status. In contrast, the social dimension (60.19) is moderately sustainable, while the economic dimension (38.92) is classified as less sustainable. The average value of all these dimensions is 70.2, which can be considered quite sustainable. Within each dimension, there are sensitive attributes that are related to its sustainable status. These attributes are a key factor in the formulation of implementation strategies to encourage food security in Kediri District. The prospective analysis of the key factors indicates that most of these factors are situated in Quadrant II, signifying a high level of influence and dependence. To promote resilience effectively and efficiently in Kediri District, it is essential to prioritize strategies that consider the pivotal factors within Quadrant II.

**Keywords:** *Food Security, Integrated Pest Management, Sustainability*

## BACKGROUND

The growing population represents a significant challenge to national food security in Indonesia. This is defined by the FAO (2003) as a situation in which everyone has access to safe and nutritious food in sufficient quantity and quality to support an active and healthy life. The dimensions of food security include availability, utilization, economy, socio-culture, and infrastructure (Rivani, 2012). Food crops are a significant contributor to the provision of dietary requirements for the Indonesian population, with rice representing a particularly prominent example. In Indonesia, rice serves as a key indicator of food security and nutritional status at the regional level. The current level of rice consumption is 132.98 kg/capita/year, indicating a pressing need to increase rice production to meet the food needs of the Indonesian population (Pusat Data dan Sistem Informasi, 2020). Furthermore, the endeavor to augment rice production through enhanced productivity is impeded by the conversion of agricultural land, climate change, deterioration of irrigation networks, and pest infestation (Purwaningsih, 2008). Furthermore, infrastructure such as dams, irrigation systems, and damaged roads have disrupted the commodity distribution system, resulting in a significant increase in transportation costs. The excessive use of chemical fertilizers and pesticides has led to a decline in natural resources and soil quality (Dzikrillah et al., 2017). In response to these challenges, the implementation of IPM (Integrated Pest Management) in East Java Province commenced in 2016. Since then, rice productivity in East Java Province has demonstrated a notable increase.

In 2022, East Java ranked first among all Indonesian provinces in rice production, with a total yield of 9,526,516 tons. However, between 2020 and 2022, the production of paddy rice exhibited a tendency towards fluctuation in value. One of the districts/cities in East Java that is notable for its rice production is Kediri District. Kediri District is one of the districts in East Java Province that still has an agricultural development area, which can be utilized as a resource for activities aimed at increasing agricultural production and farmer welfare. The optimal utilization of this potential can be achieved through the involvement of farmers. Kediri Regency has an agricultural land area of approximately 44,168.00 hectares (BPS Kediri District, 2023). The rice field agricultural land is particularly fertile, making it an ideal environment for farming. Consequently, most of the population in Kediri Regency is engaged in agricultural activities, primarily as farmers. In March 2023, the area of rice plants in Kediri District that was ready for harvest reached 14,781 hectares. However, the availability of rice may be constrained due to issues with cultivation practices, which could potentially lead to a shift in economic activities. One of the primary challenges in increasing rice production is the incidence of pests and plant diseases. Pest and disease attacks can result in a reduction in rice production. The prevalence of damage to rice plants caused by leafhopper pests was observed to be as high as 5.78% in a single village in East Java Province (Handayani, 2017).

The issues that emerge have the potential to impact the sustainability of food requirements in East Java, including in Kediri District. Given that East Java Province is a leading producer of rice with IPM at the national level, it is crucial to ensure the sustainability of IPM rice farming to support food sustainability in Kediri District. In accordance with the results of research by Judijanto et al. (2023) which states that the method of managing agricultural systems has a positive correlation with quality production results and has the potential to directly encourage food security, Wihardja et al. (2023) in their Discussion Paper argue that the challenge of Indonesian agriculture is the existence of an extensive agricultural system and the lack of assistance to farmers. Considering the increasingly extensive nature

of Indonesia's agricultural system and its concomitant lack of sustainable management, this study aims to conduct a sustainability analysis of rice farming that employs the IPM management pattern. This analysis will elucidate the significant factors requiring optimization, thereby facilitating the development of the appropriate strategic approach towards achieving food security.

## RESEARCH METHODS

### Research Location

This research was conducted in Kediri District, where the agricultural sector in Kediri District has the potential to become a food barn in East Java. This is due to the relatively high agricultural productivity, particularly in rice production, with an average yield of 62 quintals per hectare from 2019 to 2023 (Dinas Pertanian & Perkebunan Kabupaten Kediri, 2023). This study specifically sampled two villages in Ngancar District, Sugihwaras Village and Pandantoyo Village. The selection of these two villages was based on the condition that most of the population work as farmers and the location was projected as one of the areas capable of supporting food security in Kediri District. In addition, Gapoktan (Gabungan Kelompok Tani) from this area already became a partner of Bulog in the absorption of grain production as part of the pilot farmer partner program.

### Sample & Research Variable

The population of this study was individuals who work as farmers in Sugihwaras Village and Pandatoyo Village, there were at least more than 1,000 individuals who work as farmers in Sugihwaras Village (Aminati et al., 2021) and Pandatoyo Village, because both villages were one of the agricultural centers in the Kediri district. Respondent selection in this study used a purposive sampling approach to determine specific respondents and combined with the Slovin Formula to calculate the number of respondents needed.

The respondent criteria in this study were as follows: (1) Being in the productive age range of 15 - 64 years; (2) Part of a Farmer Group (Gapoktan); and (3) Practiced an IPM. Based on the Slovin Formula, assuming that the total number of farmers in the two villages is 2,000 individuals with a confidence level of 90%, it can be calculated as follows:

$$n = \frac{N}{(1 + Ne^2)}$$

$$n = \frac{2000}{(1 + 2000 \cdot (0.1)^2)}$$

$$n = 95, . \sim 100$$

Based on the calculation results, a total of 100 farmer respondents from the two villages were needed, so the sample size for this study was divided by 50 farmers in each village, for a total of 100 farmer respondents. The data were collected using an interview guide that encompasses six dimensions of sustainability, which will be analyzed in this study. This study used an adaptive six dimensions to measure sustainability that adapted from Cabezas et al. (2004) which include ecology, technology,

economy, social, and also added an institutional and policy components as part of the governance aspect that can support the entire system. Each dimension consists of 10-11 attributes, resulting in a total of 51 attributes across all dimensions. The attributes of sustainability associated with IPM rice farming in this study are based on a synthesis of previous research findings, as detailed in Table 1 below.

**Table 1.** Research variable (dimensions)

| Dimension         | Attribute                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Dimension            | Attribute                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Ecology</b>    | <ol style="list-style-type: none"> <li>1. Intensity of pest attacks.</li> <li>2. Intensity of disease attacks.</li> <li>3. Diversity of natural enemy macroorganisms.</li> <li>4. Use of organic materials.</li> <li>5. Utilization of agricultural waste</li> <li>6. Crop rotation.</li> <li>7. Simultaneous crops.</li> <li>8. OPT observation.</li> <li>9. Land resource management.</li> <li>10. Agrochemical management.</li> <li>11. Biodiversity.</li> </ol>                                             | <b>Social</b>        | <ol style="list-style-type: none"> <li>1. Benefits obtained by farmers.</li> <li>2. Farmers' experience in farming rice fields.</li> <li>3. Community views on the profession of farmers.</li> <li>4. Farmers' knowledge of IPM.</li> <li>5. Farmers' motivation in IPM rice field farming.</li> <li>6. Participating in farmer group membership</li> <li>7. Frequency of Extension.</li> <li>8. Frequency of conflicts related to IPM rice field farming.</li> <li>9. Alternative businesses other than IPM rice field farming.</li> <li>10. Farmers' perceptions and satisfaction with IPM rice field farming.</li> </ol> |
| <b>Technology</b> | <ol style="list-style-type: none"> <li>1. Application of Resistant Varieties.</li> <li>2. Application of Biological Technology.</li> <li>3. Application of Chemical Pesticides.</li> <li>4. Soil Processing.</li> <li>5. Use of Chemical and Organic Fertilizers.</li> <li>6. Application of Biological Pesticides.</li> <li>7. Planting of protective crops.</li> <li>8. Weed control technology.</li> <li>9. Product processing technology.</li> <li>10. Agricultural waste processing technology.</li> </ol> | <b>Institutional</b> | <ol style="list-style-type: none"> <li>1. Coaching and extension programs.</li> <li>2. PHT field schools.</li> <li>3. Gapoktan.</li> <li>4. Participation in training/extension.</li> <li>5. Decision making.</li> <li>6. Disaster preparedness.</li> <li>7. Financial institutions (banks/cooperatives).</li> <li>8. Business partners (formulators/saprodi stores).</li> <li>9. Institutions that guarantee product prices at harvest time.</li> <li>10. Biological agent laboratories.</li> </ol>                                                                                                                        |
| <b>Economy</b>    | <ol style="list-style-type: none"> <li>1. OPT Control Efforts.</li> <li>2. Price of biological pesticides.</li> <li>3. Price of chemical pesticides</li> <li>4. Labor costs for OPT control.</li> <li>5. Cost of biological control.</li> <li>6. Price of inputs.</li> </ol>                                                                                                                                                                                                                                    | <b>Policy</b>        | <ol style="list-style-type: none"> <li>1. The role of the central government in making PHT policies.</li> <li>2. The role of local governments in making PHT policies.</li> <li>3. Suitability of the implementation of established policies.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                    |

| Dimension | Attribute                                        | Dimension | Attribute                                                            |
|-----------|--------------------------------------------------|-----------|----------------------------------------------------------------------|
|           | 7. Selling price of grain production at harvest. | 4.        | The bias of PHT policies towards farmers.                            |
|           | 8. Selling price of output (rice).               | 5.        | Policies related to the supply chain of PHT rice farming businesses. |
|           | 9. Market opportunities.                         | 6.        | Policies related to marketing of PHT rice farming businesses.        |
|           | 10. Profits obtained by farmers.                 | 7.        | Agricultural intensification policies.                               |
|           |                                                  | 8.        | Agricultural extensification policies.                               |

## Analysis

This study employs multidimensional scaling (MDS) sustainability analysis, which has been modified to adjust to measure the level of sustainability of organic farming that employs integrated pest management (IPM), designated as RAP-IPM. This analysis is conducted by translating the results of interviews conducted with respondents into a sustainability categorization scale as follows:

**Table 2.** Sustainability index value

| Value  | Status                 |
|--------|------------------------|
| 76-100 | Very sustainable       |
| 51-75  | Moderately sustainable |
| 26-50  | Less sustainable       |
| 00-25  | Not sustainable        |

Source: Fauzi & Anna (2005)

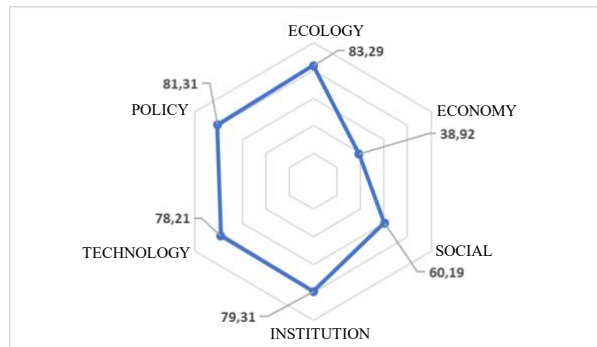
The results of the sustainability analysis serve as the basis for prospective analysis, which seeks to identify the critical factors that can enhance the sustainability of rice field farming in Kediri District.

## RESULT & DISCUSSION

### 1. Sustainability index value of rice field farming that implements Integrated Pest Management (IPM)

This sustainability index measurement employs the Multidimensional Scaling (MDS) approach, which analyzes the dimensions of the agricultural system and combines them with the attributes of each dimension that have the potential to influence the agricultural system or conditions in Kediri Regency. This research employs a total of six dimensions, encompassing 59 attributes. These dimensions are organized into the following categories: ecological (11 attributes), technological (10 attributes), economic (10 attributes), social (10 attributes), institutional (10 attributes), and policy (8 attributes).

The results of the analysis using the Multidimensional Scaling (MDS) method with the designation RAP-IPM indicated that rice field farms that implement Integrated Pest Management (IPM) exhibited a sustainability index value of 70.21, which is classified within the moderately sustainable category. A detailed representation of this finding is illustrated in Figure 1 below.



| Dimension     | Value | Status             |
|---------------|-------|--------------------|
| Ecology       | 83,29 | Highly Sustainable |
| Economic      | 38,92 | Less Sustainable   |
| Social        | 60,19 | Quite Sustainable  |
| Institutional | 79,31 | Highly Sustainable |
| Technology    | 78,21 | Highly Sustainable |
| Policy        | 81,31 | Highly Sustainable |

**Figure 1.** Index value and sustainability status of rice farming with the IPM system in Kediri Regency

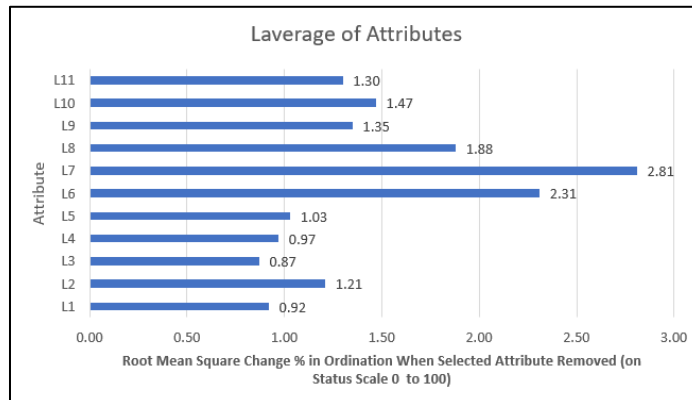
The mean value for the sustainability dimension is 70.21, which falls within the moderately sustainable category. However, when viewed individually or independently, the dimensions that are deemed to be particularly sustainable include the ecological dimension (83.29), the policy dimension (81.31), the institutional dimension (79.31), and the technological dimension (78.21). Subsequently, the social dimension (60.19) is assigned a moderately sustainable status. Conversely, the economic dimension exhibits the lowest index value, at 38.92, indicating a less sustainable status. It is therefore evident that the economic dimension represents a primary area of focus, necessitating a series of interventions to enhance its sustainability index. However, it is crucial to recognize that this does not preclude the optimization of other dimensions that have already attained a high level of sustainability. The implementation of Integrated Pest Management (IPM) is an effective method for maintaining the balance of ecosystems that exist around agricultural areas. This is achieved through the use and implementation of appropriate agricultural technology and the support of government policies that are in line with sustainable agricultural systems. Additionally, strong institutional cooperation plays a crucial role in encouraging the sustainability of rice farming, which is expected to contribute to food security in Kediri District.

Optimization and improvement of each of these dimensions can be done based on the sensitive attributes shown from the Root Mean Square value from the following Leverage analysis results.

## a. Ecological Dimension

The ecological dimension is comprised of 11 attributes, including the intensity of pest attack (L1), the intensity of disease attack (L2), the diversity of natural enemy macroorganisms (L3), and the utilization of organic materials (L4). Additionally, the utilization of agricultural waste is also included in this dimension. (L5), Crop Rotation (L6), Simultaneous Cropping (L7), Pest Observation (L8), Land Resource Management (L9), Agrochemical Management (L10), and Biodiversity (L11). The results of this analysis are presented in Figure 2 below.

The value of the ecological dimension sustainability index may be influenced by sensitive attributes, with three (out of 11) exerting a significant impact. These are the simultaneous crop pattern (L7), crop rotation (L6), and PMO observation (L8), which have been assigned values of 2.81, 2.31, and 1.88, respectively.



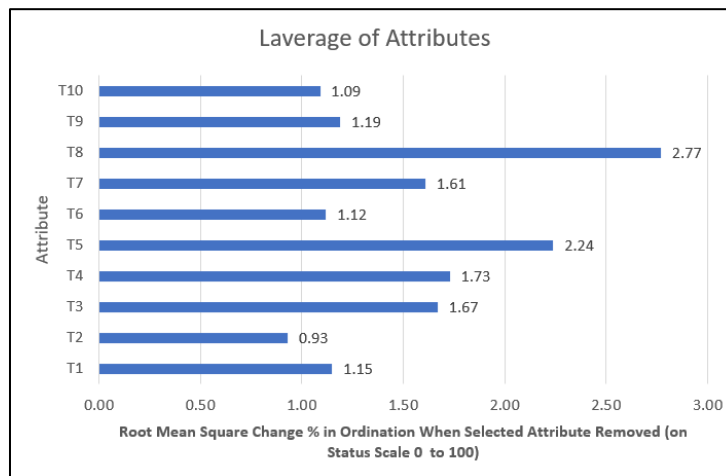
**Figure 2.** Sensitive attributes that influence the sustainability of the ecological dimension

In the Kediri District, there has been a notable decline in the utilization of agrochemicals on paddy fields. Farmers are increasingly utilizing natural input materials, such as manure derived from cow dung, compost produced from straw, and biological pesticides, in rice fields to mitigate potential environmental concerns. This is corroborated by the fact that farmers implement a simultaneous planting pattern to break the chain of pests and diseases and to enhance the efficiency of agricultural land management. In accordance with this, Atini (2022) posited that the implementation of simultaneous planting patterns in Maurisu Village can facilitate the maintenance of ecosystem equilibrium and encourage the practice of sustainable agriculture, while simultaneously deterring the occurrence of plant disease pests. The combination of simultaneous planting with regular crop rotation has been demonstrated to enhance soil fertility, stabilize the ecosystem, and prevent pest attacks. Crop rotation is a crucial practice as it can disrupt the population of pests annually and provide an opportunity for organic fertilizers to be more effective (Dadi, 2021). Additionally, it has the potential to improve soil properties that have been saturated with chemical compounds from pesticides (Suprihatin & Amirrullah, 2018). Furthermore, to guarantee that the crop pattern is conducted in accordance with organic principles, farmers in Kediri District also observe and monitor the development of pest populations. These observations are carried out on a regular and periodic basis, with the aim of acquiring knowledge regarding the development of pest populations, plant conditions, and the development of natural enemies. The results of the interviews conducted indicate that pest observations are typically conducted on a weekly basis. Subsequently, farmers provide a detailed account of the observed condition of the rice field agroecosystem, utilizing a systematic presentation format. The observations are primarily based on the examination of the symptoms of attack and the quantification of pest egg presence within the rice fields. The findings derived from these observations and monitoring activities serve as a crucial reference point for farmers in formulating their subsequent actions.

## b. Technology Dimension

The technology dimension is comprised of ten attributes, as follows: agricultural waste management technology (T1), product processing technology (T2), weed control technology (T3), planting of protective plants (T4), application of biological pesticides (T5), use of chemical and organic fertilizers (T6), tillage (T7), application of chemical pesticides (T8), application of biological technology

(T9), and application of resistant varieties (T10). The results of the leverage analysis, expressed in terms of the RMS (Root Mean Square) value, are presented in Figure 3 below.



**Figure 3.** Sensitive attributes that influence the sustainability of the technology dimension

The results of the technology dimension leverage analysis (Figure 3) indicate that five of the ten attributes analyzed have a significant impact on IPM rice farming. The five sensitive attributes with respect to the sustainability of the technology dimension, including the application of chemical pesticides (T8) by 2.77; the application of biological pesticides (T5) by 2.24; the planting of protective plants (T4) by 1.73; weed control technology (T3) by 1.67; and tillage (T7) by 1.61.

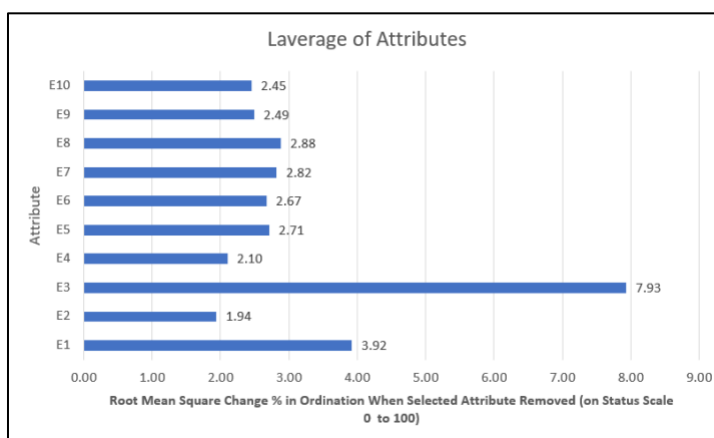
Despite the implementation of an organic farming system by farmers in Kediri, the reliance on organic materials alone is insufficient to prevent pests and avoid losses. Consequently, farmers in the Kediri district employ a combination of organic and chemical materials to promote plant growth. In this instance, chemical pesticides are employed, but only at the recommended rate for pest control, as outlined by the (Soleh, 2021). The remainder of the time, farmers utilize biological pesticides and organic fertilizers, including manure from cow dung, straw compost, and liquid organic fertilizer. The application of organic fertilizers in paddy fields has been demonstrated to enhance soil fertility, improve soil physical, chemical, and biological properties, and increase crop yields (Husna et al., 2021; Roidah, 2013). Moreover, the utilization of chemical fertilizers in accordance with the recommended dosage is also ongoing. The application of urea and phonska, for instance, is unlikely to result in adverse effects if the dosage, type, method of application, time of application, and place of application are properly calibrated (Firmansyah et al., 2017).

In order to promote ecosystem equilibrium, farmers in Kediri District also cultivate refugia plants, including sunflowers, paper flowers, and kenikir; broadleaf weeds, such as bunga tahi ayam; and select vegetables, such as corn and long beans. Refugia plants can be utilized to manage pests in rice crops. Additionally, refugia plants are readily cultivated by farmers due to their straightforward maintenance requirements and rapid growth. The rice fields in the research location also employ a pattern of tillage, whereby the topsoil layer is turned into the bottom or vice versa through hoeing, plowing, or leveling the land. This practice ensures that the soil condition remains fertile and can be planted properly (Yuda et al., 2017). Paddy fields in Kediri District are capable of being planted with rice on three occasions

throughout the year. The stages of rice field tillage are comprised of two distinct phases: initial tillage, which involves disking the soil and then spraying it with decomposer, and final tillage, which entails harrowing the soil until it becomes muddy and spreading organic fertilizer over it. This process can result in the disintegration of the soil structure into a muddy consistency, which is conducive to the cultivation of paddy rice. Rice field tillage involves the mixing and turning of the soil horizon, and the processes of pulverization and compaction can influence the nature and development of the soil profile (Agus et al., 2004).

### c. Economic Dimension

The economic dimension is comprised of ten attributes, including the profit obtained by farmers (E1), market opportunities (E2), the selling price of output (rice) (E3), the selling price of grain production at harvest (E4), and the price remaining attributes are inputs (E5), the cost of biological control (E6), labor costs of pest control (E7), the price of chemical pesticides (E8), the price of biological pesticides (E9), and pest control efforts (E10). The results of the leverage analysis, expressed in RMS (Root Mean Square) value, are presented in Figure 4 below.



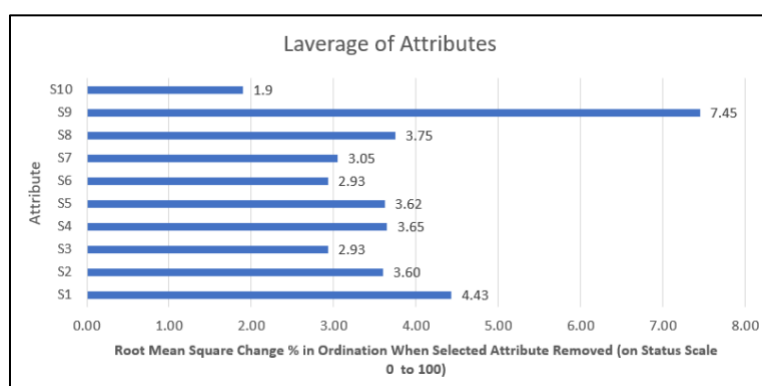
**Figure 4.** Sensitive attributes that influence the sustainability of the economic dimension

The results of the economic dimension leverage analysis (Figure 4) indicate that of the 10 attributes examined, one is particularly susceptible to influencing the cultivation of rice paddies with IPM. The attribute most sensitive to the sustainability of the economic dimension is the selling price of output (E3), which has a value of 7.93. The price of grain and rice is one of the production variables that is influenced by factors external to the farmer. The price of the output is determined by the prevailing market mechanism at the farm level (Hildayanti et al., 2013). In accordance with the findings of the research, the price of unhulled rice per sack is Rupiah (IDR). The price is set at IDR 5,000 with a slash system to middlemen, while the selling price of rice is IDR 5,000. The price per kilogram is IDR 11,000. However, when compared to inorganic rice, the price of organic rice is more expensive, and the price received by farmers is also greater. The rice sold by farmers in the Kediri District is of good quality due to its savory taste and fluffy texture. Some of the parameters that affect the quality of rice include taste,

color, aroma, composition, nutritious and clean, efficacy/benefit, and rice quality certification (Dewi et al., 2013)

#### d. Social Dimension

The social dimension is comprised of ten attributes, including perceptions and satisfaction of farmers (S1), alternative businesses other than farming (S2), frequency of conflict (S3), frequency of extension (S4), participation of farmer group members (S5), motivation of farmers to farm (S6), family participation (S7), farmer knowledge (S8), community views (S9), and farming experience (S10). The results of the leverage analysis indicate that the sensitive attributes in the social dimension are those with an RMS (Root Mean Square) value (Figure 5).



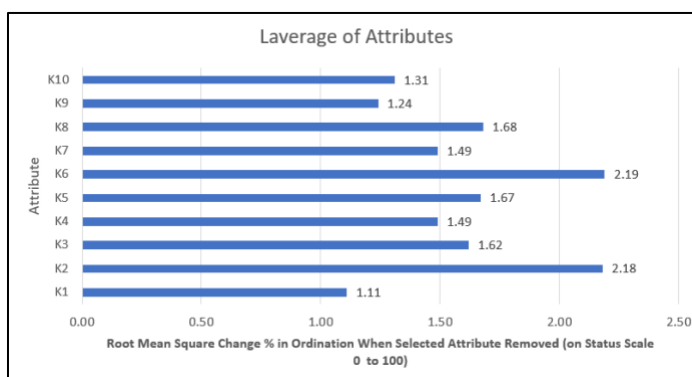
**Figure 5.** Sensitive attributes that influence the sustainability of the social dimension

The results of the leverage analysis of the social dimension (Figure 5) indicate that two of the ten attributes analyzed have a significant impact on the cultivation of rice paddies using IPM. These are the views of the community (S9) and the perception and satisfaction of farmers (S1), which have a respective leverage of 7.45 and 4.43.

Participation can be defined as the involvement of an individual or group of community members in an activity (Masitah et al., 2023). The results of the questionnaire indicate that family members are highly supportive of farming IPM rice fields. This is because the income generated from IPM rice paddy farming is higher than that obtained from conventional rice paddy farming. Moreover, the financial outlay required for the acquisition of production resources is relatively modest, with most individuals in Kediri District deriving their livelihood from the agricultural sector. The family members can benefit from the cultivation of rice paddy using IPM. Slamet (2003) posits that participation can be classified into five categories: (1) providing inputs, receiving compensation for these inputs, and enjoying the resulting benefits; (2) providing inputs and enjoying the results; (3) providing inputs and receiving compensation without directly enjoying the results; (4) utilizing the results without providing inputs; and (5) providing inputs without receiving compensation and not enjoying the results (Slamet, 2003). The level of farming experience can influence the level of ability in farming and enhance farmers' skills (Mardani et al., 2017). The average farming experience of farmers in Kediri District is 16-30 years. This condition affects productivity and success in farming. The length of farming experience is one indicator of success in farming.

### e. Institutional Dimension

The institutional dimension is comprised of ten attributes, including biological agent laboratories (K1), institutions that guarantee product prices (K2), business partners (K3), financial institutions (K4), disaster preparedness (K5), decision making (K6), participation in training/counseling (K7), farmer groups and gapoktan (K8), SL-PHT (K9), and guidance and counseling (K10). The results of the leverage analysis indicate that the sensitive attributes in the institutional dimension are those with an RMS (Root Mean Square) value (Figure 6).



**Figure 6.** Sensitive attributes that influence the sustainability of institutional dimensions

The results of the institutional dimension leverage analysis (Figure 5.6) indicate that five of the ten attributes analyzed have a significant impact on IPM rice farming. These attributes are: (1) decision making (K6), with a leverage score of 2.19; (2) institutions that guarantee product quality; The results indicate that the following attributes are particularly influential: prices (K2) by 2.18; farmer groups and gapoktan (K8) by 1.68; disaster preparedness (K5) by 1.67; and business partners (K3) by 1.62.

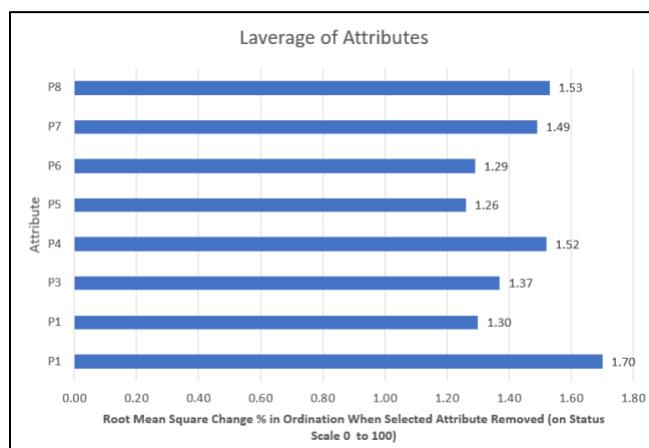
A review of data from respondent farmers in Kediri Regency revealed the absence of an institution that guarantees the price of agricultural products. Instead, there is a reliance on informal coordination between farmers and village officials. Farmers opt to sell grain to middlemen utilizing a slashing system due to its perceived convenience. The lack of support from various institutions, including the marketing of results, can negatively impact the performance of rice farming (Agustian & Rachman, 2009). The findings of the study conducted by Purwono et al. (2013) indicate that there are 12 trading channels utilized by trading institutions in Rogojampi, including rice slashers, mills, farmer groups, large traders within the district, large traders outside the district, Bulog sub-divisions, and retailers. These channels facilitate the distribution of rice from rice farmers to end consumers within and outside the district. The sustainability of rice farming businesses with IPM in Kediri Regency can be enhanced by strengthening the role of institutions in the agribusiness sector, particularly in the marketing of agricultural products.

The results of the questionnaire and farmer interviews indicate that farmers have implemented measures to prevent or prepare for the occurrence of disasters, such as pest and disease attacks, in advance. Farmers implement the Pest and Disease Control Movement (Gerdal) in rice fields. Gerdal is a preventive activity that involves the application of biological agents, including the fungus *B. bassiana*, PGPR, and POC (liquid organic fertilizer), to rice fields with the objective of anticipating pest and disease

attacks on rice plants. Farmers are reluctant to act in a responsive manner, that is, when pest and disease attacks are already imminent. Disaster preparedness is conducted in accordance with IPM principles that prioritize natural control processes (non-pesticides), which encompass appropriate cultivation techniques, the deployment of natural enemies, the use of organic fertilizers (manure and green leaf fertilizer), and the application of botanical pesticides (neem leaves, soursop, and yam gadung) (Diratmaja & Zakiah, 2015)

#### f. Policy Dimension

The policy dimension is comprised of eight attributes, including the role of the central government in formulating PHT policies (P1), the role of local governments in developing policies (P2), the suitability of implementing established policies (P3), and the support of PHT policies. The policy dimension also encompasses policies related to the supply chain of rice farming businesses with PHT (P5), policies related to the marketing of rice farming businesses with PHT (P6), agricultural intensification policies (P7), and agricultural extensification policies (P8). The results of the leverage analysis indicate that the attributes most sensitive to the policy dimension are those with the highest RMS (Root Mean Square) value (Figure 7).



**Figure 7.** Sensitive attributes that influence the sustainability of policy dimensions

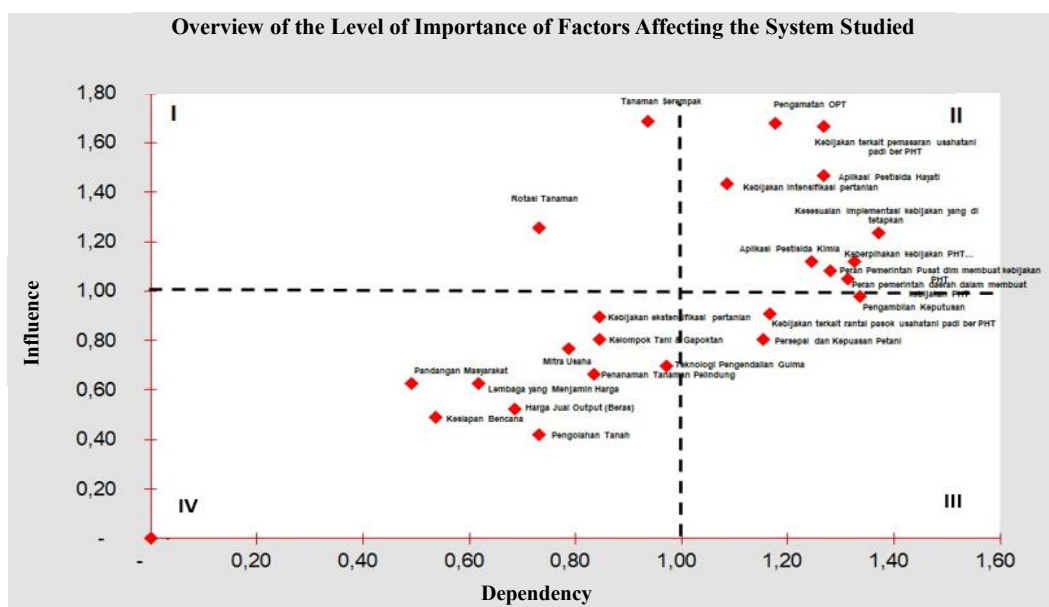
The results of the social dimension leverage analysis (Figure 7) indicate that all eight attributes analyzed are sensitive attributes that affect the rice farming business with IPM. Therefore, it can be concluded that the government has been effective and consistent in its policymaking and implementation of rice farming with IPM.

## 2. A Strategy for Enhancing the Sustainability of IPM-Based Rice Farming in Kediri Regency, Based on Key Factors

Prospective analysis is a technique used to prepare strategic objectives by determining key factors that influence various potential future scenarios. To obtain the six sustainability dimensions, a leverage analysis was conducted, resulting in the identification of 24 sensitive attributes. These attributes were derived from the following six sustainability dimensions:

1. Ecological dimensions: (1) simultaneous planting, (2) crop rotation, (3) OPT observation.
2. Technology dimensions: (1) application of chemical pesticides, (2) application of biological pesticides, (3) planting of protective crops, (4) weed control technology, (5) soil processing.
3. Economic dimension: (1) selling price of output (rice).
4. Social dimensions: (1) community views, (2) farmer perceptions and satisfaction.
5. Institutional dimensions: (1) decision making, (2) institutions that guarantee product prices, (3) farmer groups and farmer associations, (4) disaster preparedness, (5) business partners.
6. Policy dimensions: (1) The role of the central government in making PHT policies, (2) The role of regional governments in making PHT policies, (3) The suitability of the implementation of the established policies, (4) The bias of PHT policies towards farmers, (5) Policies related to the supply chain of PHT rice farming businesses, (6) Policies related to the marketing of PHT rice farming businesses, (7) Agricultural intensification policies and (8) Agricultural extensification policies.

Based on the analysis using the 24 sensitive attributes above, the following diagram was obtained:



**Figure 8** Level of importance of influential factors

The prospective analysis results, as depicted in the image, indicate that several factors exert a considerable influence on the system under study, particularly in the context of rice farming with IPM (Integrated Pest Management). These factors have been classified into four quadrants based on their level of influence and dependence. The analysis is presented below, with the variables' positions in the quadrant providing a basis for understanding the nature of their influence:

**Table 3.** Quadrant result to enhance the next strategy

| Quadrant I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Quadrant II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Simultaneous Planting: The simultaneous planting system exerts a considerable influence on the sustainability of IPM rice farming, yet this system is not overly dependent on other factors.</li> <li>• Crop Rotation: The system is highly dependent on crop rotation, yet its influence is relatively limited.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>• OPT Observation: The observation of OPT is significant, as it exerts a considerable influence and is interdependent with other factors.</li> <li>• The following section will examine the policies related to the marketing of rice farming with IPM. Local government policies pertaining to the marketing of rice farming with IPM similarly exert a considerable influence and are interdependent with other factors.</li> <li>• The Agricultural Intensification Policy is a significant factor in this context. The agricultural intensification policy exerts a considerable influence and dependence, thereby underscoring the pivotal role of this policy in ensuring the sustainability of rice farming with IPM.</li> <li>• The application of biological pesticides is a significant factor that exerts a considerable influence on the sustainability of rice farming with IPM. The utilization of biological pesticides exerts a considerable influence on several other factors.</li> <li>• Suitability of Implementation of Established Policies: The suitability of the implementation of policies established by the government also exerts a considerable influence and is highly dependent on other factors.</li> <li>• The application of chemical pesticides is a significant factor influencing the sustainability of rice farming with IPM. The use of chemical pesticides is a factor that influences and is interrelated with other factors.</li> <li>• PHT Policy Support: The support of IPM policies for farmers is an important and interdependent factor.</li> </ul> |
| Quadrant III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Quadrant IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>• Public View: Public view of rice farming with IPM has high dependency, but its influence is relatively low.</li> <li>• Institutions that Guarantee Prices: The existence of institutions that guarantee the price of rice farming products with IPM has high dependency, but its influence is relatively low.</li> <li>• Output Selling Price (Rice): The output selling price (rice) has high dependency, but its influence is relatively low.</li> <li>• Disaster Preparedness: Disaster preparedness has high dependency, but its influence is relatively low.</li> <li>• Soil Processing: Soil processing is a factor that is highly dependent on other factors, but its influence is relatively low.</li> </ul> | <ul style="list-style-type: none"> <li>• Decision Making: The decision-making process in rice farming with IPM has low influence and dependency.</li> <li>• Farmer Perception and Satisfaction: Farmer perception and satisfaction towards rice farming with IPM also has low influence and dependency.</li> <li>• Policies Related to Rice Farming Supply Chain with IPM: Policies related to rice farming supply chain with IPM have low influence and dependency.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

| Quadrant I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Quadrant II |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| <ul style="list-style-type: none"><li>• Weed Control Technology: Weed control technology also has high dependency, but its influence is relatively low.</li><li>• Agricultural Extensification Policy: Agricultural extensification policy has high dependency, but its influence is relatively low.</li><li>• Farmer Groups and Gapoktan: Farmer groups and Gapoktan are factors that are highly dependent on other factors, but their influence is relatively low.</li><li>• Planting of Protective Crops: Planting of protective crops also has a high dependency, but its influence is relatively low.</li><li>• Business Partners: The existence of business partners in rice farming with IPM has a high dependency, but its influence is relatively low</li></ul> |             |

A prospective analysis indicates that several key factors exert a significant influence on the sustainability of rice farming with IPM in Kediri Regency. These key factors are predominantly situated in quadrant II, which signifies that they exert a considerable influence and are highly dependent.

### CONCLUSION AND SUGGESTION

The sustainability status of the rice farming system with the HDI approach in Kediri District shows to has a moderate sustainable value, which is supported by the value of each dimension (six dimensions) used in the analysis. Although, four dimensions are classified as very sustainable, namely the dimensions of ecology, institutions, policies, and technology. There is a dimension that has a less sustainable status, it is an economic dimension. Based on the index value of each of these dimensions, it is necessary to pay more serious attention to the economic dimension, with a note that other dimensions classified as sustainable are comprehensively assisted so that they have an increasing sustainability value. To achieve this focused on the results of prospective analysis that shown at least 24 key attributes from all dimensions considered as a component that need to be given appropriate and increase the interventions. The results of this study can be used as a reference for the government, especially local governments, in developing appropriate strategies to achieve food security in the region. The limitation of this research is the need for various sources of information from primary and secondary data, so that it can analyze more comprehensively in accordance with conditions in the field. So, the development of this research is still very open, especially for the Government, so that it can encourage the creation of appropriate strategies to encourage food security in Indonesia.

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