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Sustainability Index of Robusta Coffee Plantation (Case Study: Wagir District Smallholder Coffee Plantation in Malang, Indonesia)

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ABSTRACT

Smallholder coffee plantation are widely distributed in Indonesia, and it also support the development of this country coffee industries. To establish the best coffee development policy in Indonesia, the analysis of sustainability index is quite important. This research wants to analyze the sustainability index in one of the potential coffee plantations in Indonesia located in Wagir District, Malang Regency. The questionnaires were distributed to 20 farmers and conducted an interview to five expert that was selected based on purposive sampling method. To elaborate the sustainability index, Multi-dimensional Scaling analysis (RAP-Coffee) was used. There are four dimensions on this analysis, namely Ecology, Economy, Social Institutions, and Technology. Analysis results showed that the sustainability index for smallholder coffee plantation in Wagir District is 43.42 (less sustainable). From dimension analysis, it is showed that Ecology dimension has four sensitive attributes, Economy has three sensitive attributes, Social Institutions has five sensitive attributes, and Technology has five sensitive attributes. To improve the Indonesia smallholder coffee plantation and industries, the policy makers must pay more attention on these sensitive attributes. So, it can encourage the formulation of strategic and targeted policies.

1. INTRODUCTION

Globally, Indonesia is included in the world's four largest coffee-producing countries after Brazil, Vietnam, and Colombia [1-3], with the proper treatment, the coffee production sector in Indonesia has an excellent opportunity to develop more. It is followed by the International Coffee Organization (2021), that state a projected 1.9% increase in coffee consumption yearly from 2019 until 2021. The most cultivated coffee in the world is Arabica coffee (Coffea arabica) and Robusta coffee (Coffea canephora), and Indonesia included as one of the most extensive robusta coffee production [2, 4].

It was recorded that from 2020, the area of coffee plantations in Indonesia (Government Estates, Private Estate, and Smallholders) reached 1,250,452 ha [5]. Although classified as having large coffee plantations, Indonesia still has obstacles competing with three other countries (Brazil, Vietnam, and Colombia). Arabica and Robusta coffee exported by Indonesia is still below the standard [6-8]. Delivery of coffee in raw materials and post-harvest handling that still uses traditional machines creates fluctuations in coffee quality in Indonesia [9]. In addition, compared to coffee plantations in three other countries, Indonesia has a large land area, but it is not followed by optimal coffee production, which is still at 811 kg/ha [5].

Large coffee plantations in Indonesia still dominate (96.19%) by smallholder coffee plantations. The area of this smallholder coffee plantation continues to increase from 1,162,810 ha (in 2010) to 1,227,191 ha (in 2020). Production of arabica and robusta coffee for smallholders in Indonesia is concentrated in 5 provinces, one of which is East Java. Robusta coffee still dominates the coffee plantation sector in Indonesia, without a total production of 81.87% of the total coffee production in Indonesia [10, 11]. Meanwhile, in East Java, Malang Regency contributed 8,455 tons (31%) of the total coffee production in Indonesia [12].

Coffee plantations in Malang Regency have been designated as one of the national plantation areas through the Decree of the Minister of Agriculture of the Republic of Indonesia (46/KPTS/PD.300/1/2015). The area of Robusta coffee plantations in Malang Regency in 2018 was 15,086 hectares with a total production of around 10,284 tons, and productivity reached 805 Kg/Ha/Year. Wagir District is one of the potential areas for the development of coffee production in Malang Regency; where Wagir District has a hilly topography and plains with an area of people's coffee plantations reaching 202 ha of the total area of Wagir District is approximately 6000 ha, or about 3.3% of the area is a smallholder coffee plantation [12]. Most coffee plantations in Wagir District, classified as smallholder plantations, still need support and improvement to achieve sustainability and provide significant economic effects to the surrounding community. For this reason, it is crucial to know the sustainability index of

smallholder coffee plantations in Wagir District because sustainability is a complex matter that links ecological, social, and economic aspects [13, 14]. The purpose of this study is to analyze the sustainability index and identify the components that influence each of these dimensions, as each dimension can affect the sustainability of the coffee supply chain, which is critical to the sustainability of the coffee plantation sector in general and the stability of the thousands of livelihoods involved [15]. It follows research from [16] on the sustainability of smallholder coffee plantations in Banyuwangi Regency. However, its status is entirely sustainable, and it requires holistically analysis, development, and improvement of all components to increase the value of the multidimensional sustainability index.

2. METHOD

2.1 Study area

Wagir District is one of Malang Regency's districts with an area of 75.43 km^2. Geographically, Wagir District is located around the foot of Mount Kawi, so hills dominate the topography. The climate in Wagir District is a tropical monsoon climate with relatively high rainfall. Due to the favorable environmental conditions, the agricultural sector is one of the leading sectors influencing the people's economy. One of the potential commodities is coffee plantation commodities which are still dominated by smallholder coffee plantations and also with traditional processing. Based on data from [12], the area of coffee plantations in Wagir District has increased by 288%, from 52 to approximately 202 hectares. This research will focus on two potential villages for developing coffee plantations: Dalisodo Village and Sumbersuko Village.

2.2 Data source

2.2.1 Sample of population

The research respondents consisted of farmers and experts. A purposive sampling method was used in the selection of respondents. Respondents among farmers were selected based on the following criteria: 1) Farmers from villages that cultivate coffee, namely Dalisodo Village and Sumbersuko Village, and 2) Members of farmer groups in these two villages. So obtained, 20 coffee farmer respondents were in this study. Meanwhile, the expert respondents from this study were selected based on the following competencies: (a) Having competence according to the field being studied, (b) Having position/position, reputation in competence with the field being studied, and having demonstrated credibility as an expert or expert in the field being studied, (c) Commit the problems studied, (d) are willing to accept the opinions of other respondents and are neutral, and (e) Have high credibility and are willing to be asked for opinions so that the expert respondents consisted of 5 people from the Department of Food Crops, Horticulture and Plantation (1 person), Coffee and Cocoa Research Institute (1 person), Academics (2 people), BAPEDDA (1 person).

2.2.2 Questionnaire

The distributed questionnaire consists of four variables related to sustainability, namely the Ecological Dimension, the Economic Dimension, the Institutional Social Dimension, and the Technological Dimension. Each of these dimensions has an attribute component used as material for analysis. The dimensions and attributes used for this research questionnaire can be seen in Table 1 below.

Table 1. Dimensions and attributes of the smallholder coffee plantation sustainability in Wagir District

Dimension	Attributes
Ecology Dimension	Land Conservation
	Waste Disposal Process
	Fertilizer Use
	Presence of Protective Plants
	Waste Utilization
	Pest Control
	Robusta Coffee Land Suitability
	Robusta Coffee Land Altitude Suitability
Economic Dimension	Determination of coffee commodity prices
	Price of input material
	Coffee business marketing
	Other income besides coffee
	Feasibility of coffee farming
Social Institutions Dimension	Availability of input/output service institutions or agencies
	Transportation facilities and infrastructure
	Ownership of farmer group legal entities
	Availability of government service agencies
	Activity in farmer groups
	The existence of farmer groups
	Frequency of coffee business conflicts
	Knowledge of coffee business
	Agricultural extension intensity
Tehcnology Dimension	Coffee bean storage
	Application of shade and intercropping technology
	Availability of agricultural information technology
	Use of agricultural cultivation machines
	Mastery of agricultural cultivation technology
	Application of agricultural technology
	Coffee harvesting method
	Application of coffee post-harvest technology

Source: Research Data, 2022 & [16] (with modification)

2.3 Analysis

The analysis in this study used the Rap-Coffee approach with the Multidimensional Scaling technique, a modification of the Rapfish method (Rapid Assessment Techniques for Fisheries) developed by the Fisheries Center [13, 17]. Multidimensional Scaling analysis that can transform dimensions is considered capable of providing comprehensive, fast, and objective results related to aspects that affect the sustainability of smallholder coffee plantations so that it can be easier to implement in policies.

Based on the studies [18, 19], there are several steps in Multidimensional Scaling analysis, (1) identify and assign attributes to each dimension and identify them through literature review and field observations; (2) Score each

attribute through an ordinal scale based on the results of field identification and interviews. (3) determine the sustainability status by conducting an MDS analysis on each dimension in the sustainability index scale; (4) Assess the 'index' and 'status' of 'sustainability' in each dimension; (5) Perform a sensitivity analysis (leverage analysis) to determine the sensitive attributes affecting sustainability; (6) Performing the calculation of the uncertainty dimension using Monte Carlo analysis.

The sustainability analysis results for each dimension can then be categorized based on Table 2 below.

Table 2. Index value of sustainability status

Index Value	Sustainability Status
0.00 – 25.00	Unsustainable
25.01 – 50.00	Less Sustainable
50.01 – 75.00	Quite Sustainable
75.01 – 100.0	Sustainable

3. RESULT AND DISCUSSION

3.1 Demographic of respondent

Respondents in this study were 25 people consisting of 20 coffee farmers and five key respondents or experts. Of the 20 coffee farmer respondents, 90% were male, and 10% were female. The age range of these respondents varies between the ages of 25-65 years, where this age range is the productive age to be able to work.

Respondents from experts consisted of 5 experts who were selected based on the following conditions: (a) Have competence according to the field being studied, (b) Have a position/position, reputation in competence with the field being studied, and have demonstrated credibility as an expert or expert in the field being studied, (c) having a commitment to the problem under study, (d) being willing to accept the opinions of other respondents and being neutral, and (e) having high credibility and being willing to be asked for opinions so that the expert respondents consisted of 5 people from the Office of Food Crops, Horticulture and Plantations (1 person), Coffee and Cocoa Research Institute (1 person), Academics (2 people), BAPEDDA (1 person).

3.2 Smallholder coffee plantation sustainability index in Wagir District

Managing smallholder coffee plantations is one of the sustainability components of coffee production. So that the sustainability analysis with an assessment of the appropriate dimensions will become a consideration for the government's strategic decision-making in developing the coffee industry, especially in Wagir District, this study analyzes four dimensions: Ecology, Economy, Social Institution, and Technology (Table 1). Each of these dimensions has attributes that are then assessed by involving research respondents. This dimension is the development of the three main pillars of sustainable development: Ecology, Economics, and Social [14].

The next step is to perform the MDS ordinance on the dimensions of the leverage factor analysis of the attributes based on the Root Mean Square (RMS) on the x-axis. The final stage is to do a Monte Carlo analysis to determine the effect of error in scoring. Leverage analysis (referring to the largest Root Mean Square (RMS) value) and Monte Carlo (if the simulation results have slightly different ordinate values, then the MDS ordinated results have been able to overcome random errors) [20].

The results of the analysis of the sustainability index are obtained by measuring the four existing dimensions. The average value of the sustainability index of the four dimensions is 43.42%, which indicates that the people's coffee plantations in Wagir District are still not sustainable. Table 3 and Figure 1 show the sustainability index value of each measured dimension.

Table 3. The average value of the analysis of the sustainability index of smallholder coffee plantations in Wagir District

VARIABEL	Rap-Coffee	MONTE CARLO
ECOLOGY	68.75	68.75
ECONOMY	24.91	24.91
SOCIAL INSTITUTIONAL	32.35	32.35
TECHNOLOGY	47.68	47.68
TOTAL	43.42	43.42

Source: Research Analysis (2022)

The results of the Monte Carlo simulation on each dimension with a 95% confidence level show no difference, so it can be assumed that there is accuracy in the MDS ordinated analysis in assessing an object.

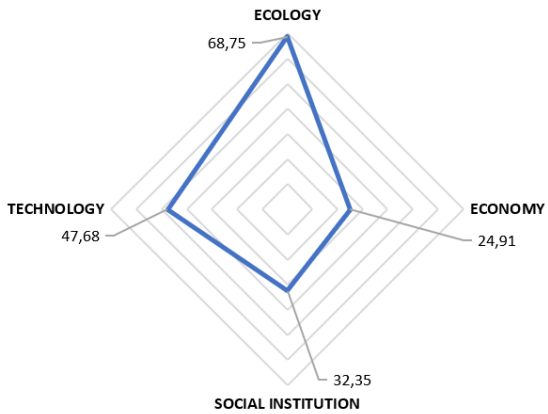

Figure 1. Kite diagram of the sustainability status of smallholder coffee plantations in Wagir District

The ecological dimension has a value of 68.75 (very sustainable), the technological dimension has a value of 47.68 (less sustainable), the social institution's dimension is worth 32.35 (less sustainable), and the economic dimension is 24.91 (less sustainable). The ecological dimension has a high index value, which shows that the condition of the ecosystem in the smallholder coffee plantations in Wagir District is classified as excellent and sustainable. However, other dimensions are still classified as less sustainable, so it is essential to know the sensitive and vital attributes to pay attention to achieve sustainability. Therefore, it is necessary to develop and improve not only on specific dimensions but as a whole or holistically on each dimension to improve the multidimensional sustainability index value because the attributes in each dimension are interrelated.

3.3 Sensitive attributes of sustainability of people's coffee plantations in Wagir District

Leverage analysis was used in this study to identify the sensitive attributes of each dimension in the sustainability of smallholder coffee plantations in Wagir District (Figure 2 – Figure 5). Leverage or sensitivity is an analysis carried out to determine the attributes that are sensitive or affect the sustainable index value, which refers to the Root Mean Square (RMS) value that encourages the sustainability of an area's development [21]. Determination of sensitive attributes that affect the sustainability of the ecological dimension using a combination of leverage analysis and Pareto analysis [22]. Pareto analysis is carried out by compiling the RMS value from the highest to the lowest value, then weighted in percentage and then accumulated to the maximum cumulative value limit of 75% [23].

3.3.1 Ecology dimension

In measuring the sustainability index, the ecological dimension consists of eight attributes: (1) water utilization, (2) waste disposal process, (3) land conservation, (4) presence of protective plants, (5) usage of organic fertilizer, (6) pest control, (7) suitability of robusta coffee plantation altitude, and (8) robusta coffee level suitability. Each attribute has a Root Mean Square (RMS) value, indicating how much sensitivity or influence each attribute has (Figure 2).

There are five of the eight attributes classified as sensitive to sustainability from the ecological dimension, namely (1) land conservation (RMS: 9.09), (2) waste disposal process (RMS: 7.14), (3) Organic Fertilizer usage (RMS: 6 .57), (4) Presence of Protective Plants (RMS: 6.51), and waste utilization (RMS: 4.92).

Land conservation is an important thing that must be considered to achieve sustainability because soil conservation plays a role in maintaining and improving the soil's chemical, physical and biological properties [24]. Coffee farmers in Wagir District have not yet fully carried out land and water conservation activities optimally. So far, making simple rorak is still an easy and inexpensive option. Rorak is a form of soil and water conservation activity that is suitable to be applied to locations with sloping topography and high rainfall. Making optimal and appropriate rorak is important in land and water conservation because rorak has a function as a temporary water reservoir that aims to prevent erosion and maintain the soil's physical, chemical, and biological properties of the soil [25] and reduce the rate of erosion runoff and maintain nutrients in the soil [26]. In coffee plantations, making rorak according to the land area has been proven to improve the quality of the surrounding soil (Satibi et al., 2019) and can meet the water needs of the coffee plant (approximately 180 m3/ha/day) with the assumption that per -hectare there are approximately 336 rorak [27]. In addition to making rorak, managing waste generated from the robusta coffee production process also plays a role in the ecological dimension. The surrounding community still has the habit of throwing garbage in holes made in the yard or plantation, which will then be burned. It will lead to contamination of the quality of the soil and air around it. Robusta coffee post-harvest activities in Wagir District also have the potential to produce organic waste depending on the drying method used. Most coffee farmers in Wagir District still use the dry drying method. This drying process has two impacts; the first is that the coffee beans produced have a lower selling value, are easy to mold, and have a less pleasant aroma [28], and the second is the potential for waste generated. Based on the study [29], the management of robusta coffee could produce 35% of waste that is rarely used by the surrounding community. So far, the use of coffee waste is still in its use as plant fertilizer, even though the opportunity for developing coffee waste is quite large if it can increase its added value.

The use of organic fertilizers as a driving force for coffee growth has not been carried out optimally. Although some farmers have used waste from coffee processing in organic fertilizers, most people prefer to use chemical fertilizers that have been mixed with a certain dose, which according to them, is more effective and cheaper. However, if viewed from a sustainability perspective, using chemical fertilizers will impact decreasing soil and water quality [30, 31].

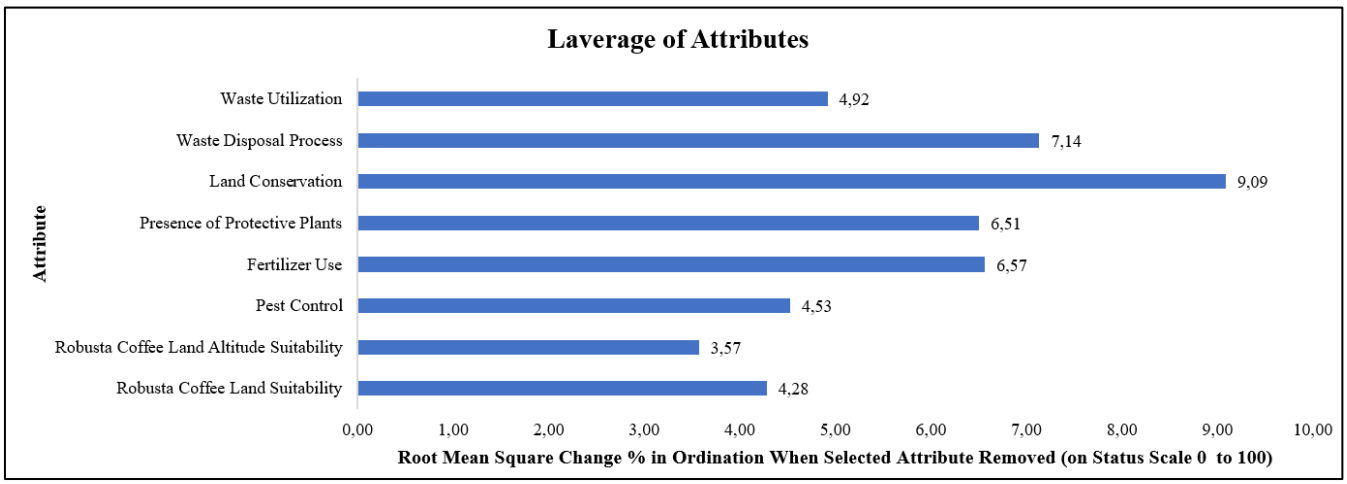

Figure 2. Leverage analysis of ecology dimensions

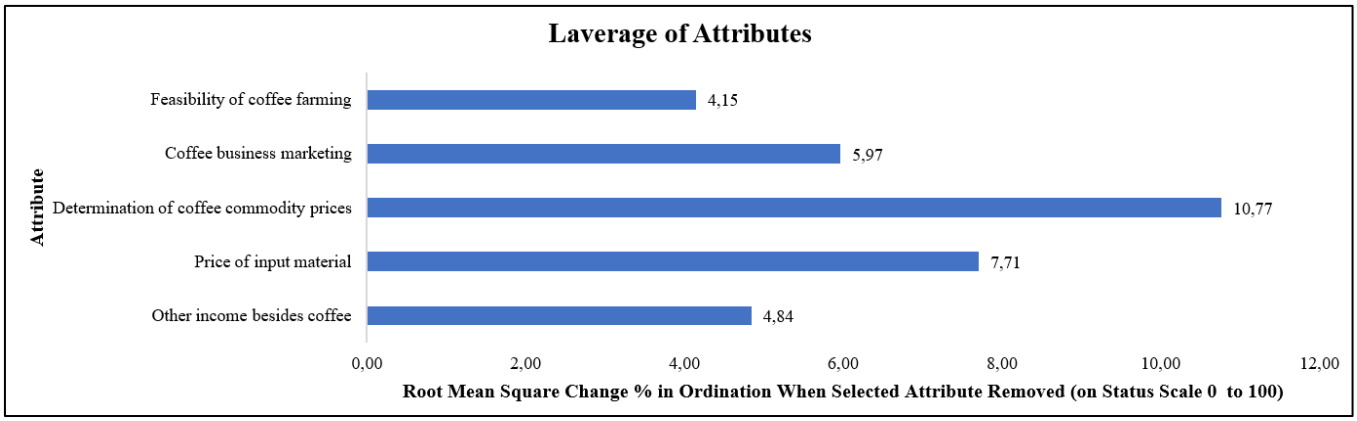

Figure 3. Leverage analysis of economic dimension

The use of appropriate organic fertilizers, apart from playing a role in land conservation, also plays a role in maintaining the productivity of coffee plantations. The use and application of organic fertilizers can improve the soil's chemical, biological, and physical properties. It is also environmentally friendly, inexpensive, and can improve product quality and soil fertility in the long term [32-34]. The existence of protective plants or shade plants around coffee plantations plays a role as a factor for growth and increasing coffee productivity. It is because the shade plants can provide the optimal amount and distribution of sunlight for the growth and development of coffee plants [35]. Most farmers have cultivated protective plants along with the coffee plant. In people's coffee plantations, the commonly used shade trees include dadap, avocado, petai, jengkol, breadfruit, lamtoro, and sengon [36]. The proportion of shade plants also needs to be considered because it is related to the density of existing plants [37]. Plantations with narrow distances will cause the intensity of sunlight to decrease, which in turn can affect coffee plants' fertility and impact their productivity.

3.3.2 Economic dimension

The economic dimension consists of five attributes: (1) the feasibility of coffee farming, (2) coffee business marketing, (3) the determination of coffee commodity prices, (4) the process of input material, and (5) other income besides coffee. The sensitivity of the economic dimension will affect the development plans and policy recommendations that can be provided to the local government. The RMS value of each of these attributes can be seen in Figure 3.

The economic dimension consists of five attributes, with three attributes that are sensitive to sustainability, namely (1) Determination of coffee commodity prices (RMS: 10.77), (2) Price of input material (RMS: 7.71), and Coffee business marketing (RMS: 5.97).

The price of coffee commodities at the farmer level in Wagir District is determined based on the quality of the coffee beans produced. The price of coffee in Wagir District reaches IDR 25,000/kg. However, coffee prices have been relatively low, from IDR 20,000 to IDR 25,000 since 2000. Whereas in 2020, the international price of coffee will reach US$ 2.42 per kilogram, equivalent to IDR 34,100. With this high price difference, farmers are still at a disadvantage because they cannot cover operational costs, and the current price is still below what is expected. According to Fitriani et al. [3], 76% of Indonesian coffee prices are influenced by changes in international coffee prices. The stability of the price of Robusta coffee beans tends to be low, one of which is caused by the factor of middlemen who usually buy coffee at a price that differs quite a lot from the price on the market, so farmers do not benefit amidst the current high demand for coffee [38]. However, farmers also have no choice because of the difficulty in marketing their coffee plantation products to large agents, so middlemen are still the main choice for coffee farmers in Wagir District. In line with this, Pratiwi and Salim [26] stated that the close distance, the ease of borrowing money to cover production capital, and the absence of special treatment for coffee made coffee farmers prefer to sell their products to middlemen. So, it takes a good marketing channel to create a sustainable coffee ecosystem. One of the steps is to build an Agropolitan system, one of the distinctive, popular, and efficient urban development concepts for more than one purpose, designed for urban areas and becomes the center of local market planning. This concept is based on the benefits and disparities of capital flows between cities and villages. Agricultural products will be processed before being traded to a wider market [39]. This process will increase local value and maintain local economic components [40, 41].

Input prices are included in factors that will affect production costs. The higher the input price, the more expensive production costs will be, but what happens in the field is that high production costs are not followed by commensurate commodity selling prices and are often below the average market price [42-44]. Research from [45-49]. have shown that changes in input prices have a more significant effect on the harvested area and changes in productivity. Input price factors such as substitute commodity prices and interest rates significantly negatively affect the area of an agricultural commodity, both food and plantation. In addition, output prices, input prices (fertilizers), and time trends (technology) all have a significant impact on the productivity of food crops or plantations [45, 47, 50, 51].

3.3.3 Social institution dimension

The social dimension of the institution is related to the community's social conditions and the institution's role in developing the sustainability potential of smallholder coffee plantations in Wagir District. The institutional social dimension consists of nine attributes, namely (1) the existence of farmer groups, (2) transportation facilities and infrastructure, availability of government services agencies, (3) the role of financial institutions, (4) ownership of farmer group legal entities, (5) activity in farmer group, (6) frequency of coffee business conflicts, (7) knowledge of coffee business, and (8) agricultural extensions intensity. The sensitivity value of the institutional social dimension can be seen in Figure 4.

The social dimension of the institution consists of nine attributes, of which five include attributes that are sensitive to sustainability. The attributes are the role of financial institutions (RMS: 6.64), Transportation facilities and infrastructure (RMS: 6.57), Ownership of farmer group legal entities (RMS: 6.22), Availability of government service agencies (RMS: 6.02), and Activity in farmer groups (RMS 5.58).

Most coffee farmer communities in Wagir District still use their capital (money) to fulfill the needs of the production process and the development of their coffee plantations, rather than having to access formal financial institutions for more capital needs. This result is in line with the research on vegetable farmers conducted by Sudiono et al. [52], where farmers do not have access to formal financial institutions to increase their farming capital. For this reason, it is necessary to increase the role of financial institutions as a source of capital for farmers [1]. Capital institutions such as cooperatives, banks or other financial institutions are indispensable in supporting the sustainability of smallholder coffee plantations on the institutional dimension, so that coffee farmers do not fall into illegal loans, which can later worsen economic conditions [53]. Infrastructure development and conditions also play a role in the productivity of smallholder coffee farming [54]. The condition of infrastructure and transportation in the people's coffee plantations in Wagir District is quite good. It is indicated by the standard main road access and the existence of markets to sell the community's coffee production. Transportation is also no longer a significant obstacle because most farmers have private vehicles to transport their harvests, coupled with the presence of middlemen who are usually present on the plantation land to pick up production products on site. This ease of selling coffee production makes many farmers rely on middlemen to buy their produce, although sometimes the prices are still far below the standard [1, 51, 55, 56].

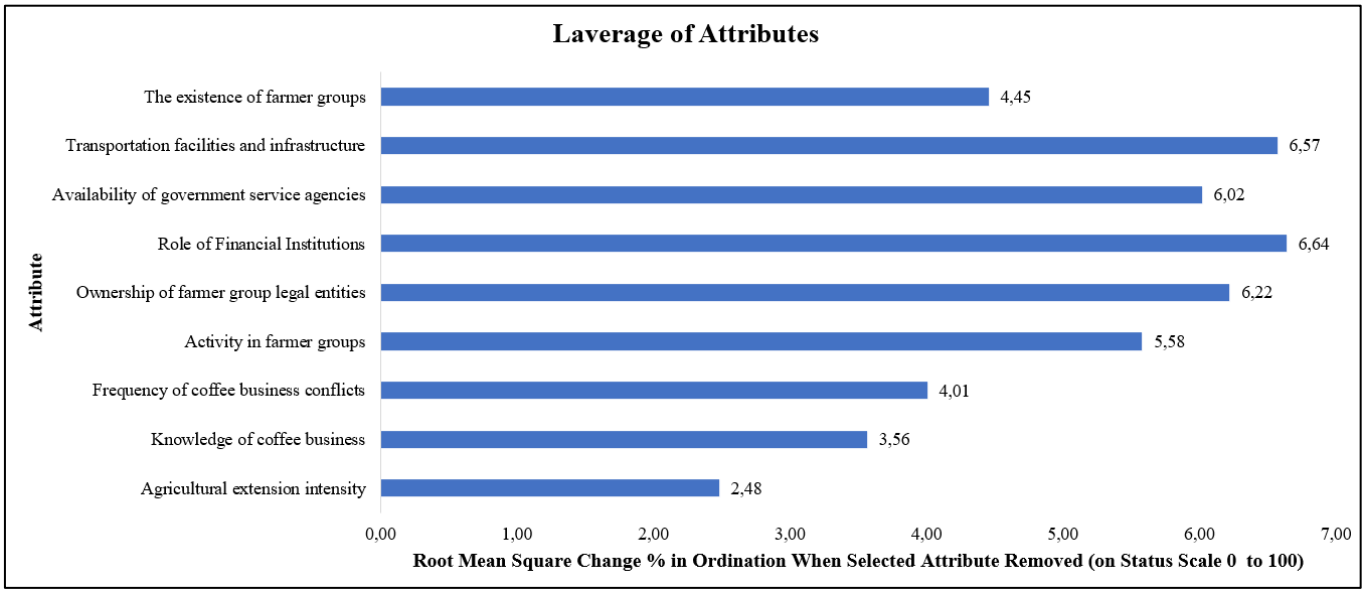

Figure 4. Leverage analysis of social institutional dimension

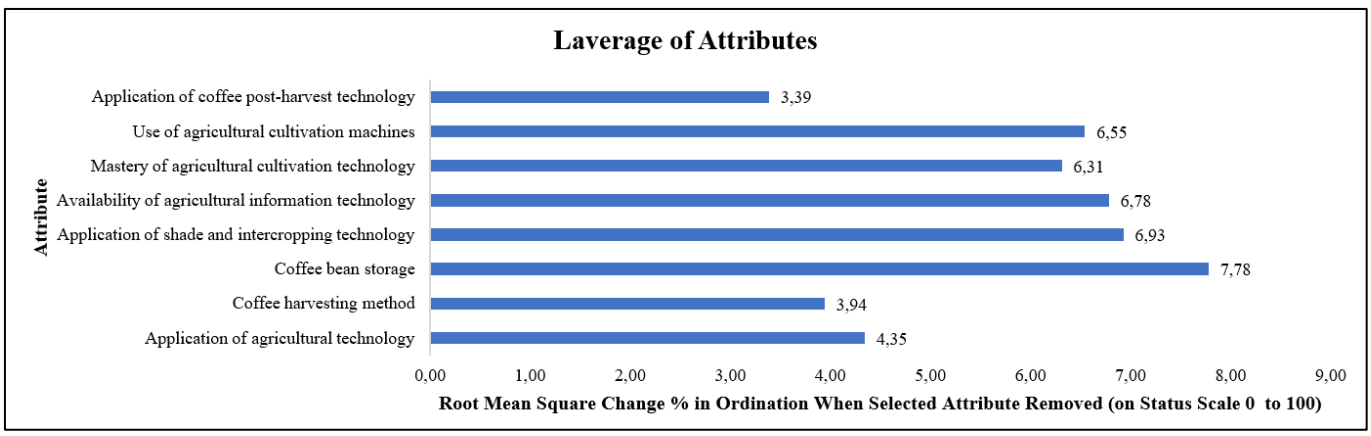

Figure 5. Leverage analysis of technology dimension

Farmer groups become a forum for coffee farmers in Wagir District to discuss and prepare for the development of their production. However, there are at least two important components of farmer groups that need to be considered for the Wagir sub-district, namely (1) the legal entity of the farmer group and (2) the activity of the farmer group (both in groups and individually). Legal entities from a farmer group can provide greater opportunities to get support from the government and the private sector, thereby facilitating the opportunity to obtain financial support from banks and

increasing the sustainability of coffee farming [49, 57]. Farmer groups in the research area have been formed, and regular group meetings are held monthly. However, some farmer groups have not regularly held group meetings to exchange information related to coffee farming. Farmer group administrators have not been able to facilitate their members optimally. It is indicated by the lack of participation of members of farmer groups in meetings and farming activities that are not yet market-oriented. The role of government, in this case, the central and regional agencies related to plantations for the development of coffee farming, has played an active role by providing facilities in the form of coffee seed assistance, subsidized fertilizers, post-harvest tools and product processing, coaching in the form of training, facilitation of organic coffee certification and others. Other. The government's attention to promoting coffee in Malang Regency is quite large. The guidance and mentoring carried out by agricultural extension officers have been carried out routinely during group meetings. However, the limited number of extension officers, the time for group meetings that are mostly carried out at night, and the number of activities that implement extension services cannot be maximized.

3.3.4 Technology dimension

The technological dimension relates to equipment and methods for preparing, processing, and producing coffee. The technology dimension consists of eight attributes, namely (1) Coffee bean storage, (2) Application of shade and intercropping technology, (3) Availability of agricultural information technology, (4) Use of agricultural cultivation machines, and (5) Mastery of agricultural cultivation Technology, (6) Application of agricultural technology, (7) Coffee harvesting method, and (8) Application of coffee post-harvest technology. The sensitivity value of the technology dimension can be seen in Figure 5.

The technology dimension consists of eight attributes. Based on the results of Leverage analysis and Pareto analysis, five attributes are sensitive to sustainability, namely Coffee bean storage (RMS: 7.78), Application of shade and intercropping technology (RMS: 6.93), Availability of agricultural information technology (RMS: 6.78), Use of agricultural cultivation machines (RMS: 6.55), and Mastery of agricultural cultivation technology (RMS: 6.31).

Many farmers in Wagir Sub-district still do simple coffee bean storage, some of which do not even have a standard storage process. Storage carried out is still limited to using used sacks and stored in an empty place without regard to the physical condition of the environment. The storage of wet and processed coffee beans affects the water content they contain [54, 58]. At least, it is necessary to socialize and train coffee farmers to understand the steps for storing harvested coffee beans, so it does not reduce the quality of robusta coffee beans from smallholder coffee plantations in Wagir District. The cropping patterns applied by farmers are diverse, namely multi-strata, intercropping, livestock integration and a small part of monoculture. The average farmer implements an intercropping system with seasonal crops: banana, coconut, clove, salak, durian, and chili. In addition to seasonal crops, they also plant annual crops such as sengon and jabon. These plants functioned as a shelter or to earn additional income. The shade plants planted are banana, durian, lamtoro, sengon. This diversity of shade plants provides economic benefits that farmers can directly enjoy. These benefits come from agricultural products and reduced labor use. However, farmers must pay attention to the pattern of arrangement of the composition, amount, and method of managing shade plants properly because it is related to efforts to maintain economic and ecological functions in coffee farming [59-61].

In terms of coffee cultivation technology according to the principles of good and correct coffee cultivation (GAP coffee), farmers have not yet fully implemented it even though, according to Novita et al. [62], the success of correct post-harvest handling is very dependent on seeding activities and the cultivation process. Coffee production activities in Wagir District are mostly maintenance, including fertilizing, pruning, spraying, weeding, and harvesting [62], For pruning activities, only a few farmers prune the coffee plant, but for the shape and post-harvesting prune it is still rarely done. It can make the quality and quantity of the coffee beans for the next harvest to decrease. The poor condition of the plantations indicates it the productive branches are not shaped in such a way that they are shaped like umbrellas. The less intensive post-harvest pruning will affect the productive branches, impacting the resulting coffee production [63].

4. CONCLUSION

Sustainability index of smallholder coffee development in the Wagir District is 43.42 (less sustainable). It shows that many attributes still need to be considered, improved, and developed from all dimensions to encourage smallholder coffee plantations in the Wagir sub-district to be more sustainable. From each of the analyzed dimensions (ecological, economic, social, and technological), there are sensitive and large influences on several attributes. In the ecological dimension, there are four sensitive attributes: land conservation, waste disposal process, Organic Fertilizer usage, Presence of Protective Plants, and waste utilization. In the economic dimension, there are three sensitive attributes: Determining coffee commodity prices, Price of input material, and Coffee business marketing. The institutional social dimension consists of five sensitive attributes, the role of financial institutions, Transportation facilities and infrastructure, Ownership of farmer group legal entities, Availability of government service agencies, and Activity in farmer groups. The Technology dimension consists of five sensitive attributes: Coffee bean storage, Application of shade and intercropping technology, Availability of agricultural information technology, Use of agricultural cultivation machines, and Mastery of agricultural cultivation technology.

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