Sustainability of Maize Farming in Grobogan, Central Java. Indonesia

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Abstract. Grobogan district is the center for maize cultivation in Central Java province with production contribution of 21.8% in 2016. The types of agricultural land in this district is moor and forest land (pesanggem), thus it is interesting to study the sustainability of maize farming in this location. Farmers are taking consideration of sustainability in terms of land, social, economy and agronomy for the next generation. This study aims to (1) describe maize farming implementation, (2) analyze maize farming sustainability and (3) formulate the efforts to improve maize cultivation sustainability in Grobogan district. Descriptive analysis Majewski Index and SWOT were applied to analyze the data. The results showed that (1) farmers tried to increase production by applying "siti methuk" cultivation technique, where farmers began planting again even though the maize had not been harvested (2) the order of priority for sustainability by farmers is the aspect of land - social - economic - agronomy. The average score of sustainability analysis with The Synthetic Farm Sustainability Index of Majewski is 51.15, (3) the alternative sustainable improvement of maize farming such as subsidies for the price of inputs, facilitation of land conservation infrastructure with deep wells, and seed price subsidies.

1. Introduction
Maize commodity occupies an important position in the Indonesian economy as a source of carbohydrates, feed ingredients and food raw materials. In addition to the seeds, biomass from forage maize is also needed in the development of cattle.

Grobogan District is a center of maize production in Central Java Province. Based on the data from Central Bureau of Statistics (BPS), within a decade and a half, maize production increased by 34.2% from 461,085 tons in 2001 to 700,941 tons in 2015 with the harvest area of 112,700 hectares [1].

The majority of farmers in Grobogan District cultivate the dry lands to meet the demand for maize. The unique nature of drylands is that the soil is sensitive to erosion, slope and poor in nutrients. The majority of farmers cultivate maize on farmland, while some other farmers are Pesanggem farmers, which means planting maize under the forest stands owned by PERHUTANI.

Maize is a commodity that has bright prospects because the opportunity of potential markets is widely opened both inside and outside Grobogan District. Furthermore, it is also highly needed for processed products (21 industries) and raw materials of animal feed industry (14 industries) in 2018.

Based on the previous study from [2] the economic efficiency of maize farming in Grobogan District was 0.332. This condition was caused by limited farmers' capital, expensive production prices, and fluctuating product prices. Agriculture did not provide sufficient income for farmers even though they had a long history in cultivating maize on their land. Moreover, dryland conditions cannot guarantee the sustainability of maize farming.
Table 1. Maize production in 2001-2015 in Grobogan District

| Year | Production (tons) | Growth Δ (%) |
|------|------------------|--------------|
| 2001 | 461,085          | 0.00         |
| 2002 | 301,662          | -34.58       |
| 2003 | 612,661          | 103.10       |
| 2004 | 483,560          | -21.07       |
| 2005 | 653,742          | 35.19        |
| 2006 | 424,117          | -35.12       |
| 2007 | 518,676          | 22.30        |
| 2008 | 723,747          | 39.54        |
| 2009 | 705,691          | -2.49        |
| 2010 | 708,013          | 0.33         |
| 2011 | 502,212          | -29.07       |
| 2012 | 575,614          | 14.62        |
| 2013 | 559,555          | -2.79        |
| 2014 | 590,776          | 5.58         |
| 2015 | 700,941          | 18.65        |
| Total| 8,522,052        | 114.17       |
| Average| 568,137          | 7.61         |

Recently, research on maize commodities has focused more on the costs of farming income, demand or supply of maize using secondary data. Given that maize is an important commodity, serious efforts are needed to ensure its availability in the long run. This paper examines in more detail about the sustainability of maize farming in terms of economic, social, land, agronomic, and agricultural management aspects. The recommendation of this research is expected to be one of the foundations for realizing Central Java as one of the central region of maize production in Indonesia. This study has the following objectives: 1) describing the implementation of maize farming, 2) identifying the sustainability of maize farming and 3) formulating alternative efforts to increase the sustainability of maize farming in Grobogan District.

2. Materials and Methods
   The basic method used in this study was descriptive analytical method [3]. Determination of the research location was carried out purposively with the highest production consideration. Two sub-districts were chosen, namely Toroh Sub-district and Geyer Sub-district with 45 respondents.

   In conducting data collection, interviews, recording, observation and Focus Group Discussion (FGD) techniques were used. The participating stakeholders were farmers, BPP, BAPPEDA, Environment Agency, Department of Agriculture, Food Crops, Horticulture, Plantation and Forestry, Department of Industry and Trade, and Food Security Agency. The types of data used were primary and secondary data.

   To find out the implementation of maize farming was done by descriptive analysis. The sustainability of farming was analysed by the Synthetic Farm Sustainability Index (SFSI) using Multiple Weight Method (MWM). The indicator used is a combination of The Upland Ecosystem on household scale [4,5] and the synthetic farm sustainability index [6]. The steps to obtaining the Sustainability Index are:
   a. Determine the score of each item, the score with a range between 0 (most disadvantage) to 10 (most profitable)
b. Determine the weight of each category
c. Calculate the Partial Sustainability Index, namely the multiplication of item scores and weights
d. Calculate the Synthetic Total Sustainability Index (SFSI).

SFSI is obtained by calculating and comparing the partial indicator weights into group weights and their sums. The total sustainability index is grouped into five categories, namely (1) 0.00 - 0.20; (2) 0.21 - 0.40; (3) 0.41 - 0.60; (4) 0.61 - 0.80; (5) 0.81 - 1.00.

Formulation of alternative efforts to increase the sustainability of maize farming was conducted by SWOT analysis.

3. Result and Discussion

3.1. Description of maize farming in Grobogan District

Grobogan District is located between 1100 15' BT - 1110 25' BT and 70 30' LS with an area of 197,586.42 Ha. Most areas are situated on relatively flat surfaces with slopes of less than 5%, hilly and mountainous regions. In 2016 the agricultural sector made the largest contribution to the Gross Regional Domestic Product amounting to 31.77%.

Table 2. Characteristics of farmers’ household.

| Description          | Number of farmers | %   |
|----------------------|-------------------|-----|
| Land area (hectares) |                   |     |
| <0.3                 | 19                | 42.2|
| 0.3-0.5              | 14                | 31.1|
| 0.5-1                | 3                 | 6.7 |
| >1                   | 9                 | 20.0|
| Age (years)          |                   |     |
| <40                  | 7                 | 15.6|
| 50                   | 12                | 26.7|
| 60                   | 13                | 28.9|
| 70                   | 13                | 28.9|
| Education (years)    |                   |     |
| <6                   | 9                 | 20.0|
| 6                    | 24                | 53.3|
| 9                    | 7                 | 15.6|
| >=12                 | 5                 | 11.1|

Table 2 shows that the majority of farmers cultivated less than 0.3 hectares of maize. On average, the cultivated land ranges from 0.46 hectares for self-owned land and 0.30 hectares for rent. The efforts of farmers to increase the planting area were done by renting, profit sharing, and working on forest land owned by PERHUTANI (refer as pesanggem). It can be seen that 20% of farmers cultivated more than 1 hectare of land, which considerably high compared to land ownership by other food commodity farmers. Efforts to increase production were carried out using the Siti Methuk technique, where farmers began planting again even though the maize had not been harvested.

In term of the age, it is clearly seen that maize farmer households were still dominated by old farmers. Farmer regeneration efforts are needed considering that only 15.6% of farmers were young (<40 years). Moreover, formal education of farmers was limited to graduating from elementary school (6 years) and rarely attending non-formal education.

In carrying out its farming, farmers encountered several problems, including the erratic rainfall over the past few years, so farmers tried to be adaptive and flexible to these conditions. Farmers often had difficulty getting enough seeds, fertilizers, and pesticides in the right amount of time. As the response to this problem, farmers bought makeshift inputs from nearby neighbours or shops, this affected maize production.
Even though it is classified as labour-saving, farmers were still having difficulty obtaining workers so that they often had to fight with other farmers. The usual solution was to bring in workers from outside the region with the consequence of more high wages. Farmers also maximized the use of family labour to reduce the cost of farming. Another problem faced was related to product marketing because farmers were only a price taker.

3.2. Sustainability of maize farming in Grobogan District

Sustainability of maize farming using SFSI approach is calculated by MWM. SFSI consists of 4 categories, namely (1) economic sustainability (consisting of 11 items); (b) social sustainability (consisting of 7 items), (2) land sustainability (consisting of 8 items) and (d) agronomic and farm management sustainability (consisting of 8 items).

The economic sustainability category describes the assets owned and farmers’ access to economic facilities. Furthermore, it also explores information related to income regarding diversification, profits and business orientation.

**Table 3.** Score of economic sustainability category on maize farming in dry lands in Grobogan District in 2016.

| Economic Sustainability Category                              | Average | Minimum | Maximum |
|---------------------------------------------------------------|---------|---------|---------|
| Area of agricultural land                                    | 2.38    | 1       | 9       |
| Number of field area                                          | 3.16    | 1       | 8       |
| Source of income diversification                              | 3.07    | 1       | 10      |
| Income instability                                            | 3.69    | 1       | 8       |
| Agricultural net profit                                       | 4.13    | 1       | 10      |
| Instability of outputs                                       | 4.69    | 2       | 9       |
| Parts of products sold                                        | 9.00    | 9       | 9       |
| Effectiveness of fixed assets                                 | 6.59    | 1       | 10      |
| Credit taking opportunities                                   | 2.87    | 1       | 8       |
| Share of credits repayment in personal income                 | 1.91    | 1       | 3       |
| Household food security                                       | 6.89    | 6       | 8       |
| Total                                                         | 43.97   | 25.64   | 57.27   |

For villagers, the house is not only a place to live, but also as a symbol of social status. It can be seen in the table that all farmer households owned a house even with minimal facilities / furniture. The results of the study show that farmers did not have much role in farmer groups, general training or occupying important positions in the social hierarchy. This condition will prevent farmers from advancing both in cultivation and business management.

Based on Table 3, it can be seen that economic sustainability needs to be improved because the average scores of each items are low. Limited capital, land area, income, output instability is endless circles of poverty. Credit facilities were expected to be able to break the problem, but it has not been widely used by farmers. Even so, farmers were still in the food resistant category. The tendency of low income households is when the largest proportion of expenditure is their food needs. The research simulation [7] states that a policy of increasing fertilizer price subsidies by 25% can reduce the cost of maize production (2.076%) so that it can increase the total farming profit by 2.39%.

The social sustainability category explains about the ability of self related to education and ownership and facilities of housing. This category also assesses the accessibility, position and participation of farmers in community life.
Table 4. Score of social sustainability category on maize farming in dry lands in Grobogan District in 2016.

| Category                                | Average | Minimum | Maximum |
|-----------------------------------------|---------|---------|---------|
| Level of education                      | 4.62    | 1       | 8       |
| Housing ownership                       | 10.00   | 10      | 10      |
| Household facilities                    | 4.84    | 2       | 8       |
| Accessibility of social services        | 5.07    | 3       | 9       |
| Position in the social hierarchy       | 3.38    | 2       | 5       |
| Participation in farmer groups          | 1.80    | 1       | 4       |
| Training participation                  | 1.44    | 1       | 2       |
| **Total**                               | **44.51**| **32.86**| **64.29**|

From Table 4, we can see that the value of social sustainability is 44.51 which considered as low. This result is consistent with previous studies that to empower farm workers and to create production conditions that are favourable to a broader conception of social justice, change is needed in the agro-food system as a whole, not just at the point of production [8]. Social factors seem to have more impact than biophysical factors on the decision to integrate agroforestry intercropping systems in intensive and extensive agricultural landscapes. [9]

Table 5. Score of land sustainability category on maize farming in dry lands in Grobogan District in 2016.

| Category                                | Average | Minimum | Maximum |
|-----------------------------------------|---------|---------|---------|
| Rocks existence                         | 5.93    | 3       | 9       |
| Land erosion threat                     | 8.00    | 8       | 8       |
| Terrace reinforcement plants            | 5.33    | 1       | 8       |
| Terrace percentage                      | 7.27    | 1       | 9       |
| Terrace quality                         | 7.27    | 2       | 9       |
| Type of terrace                         | 7.18    | 2       | 9       |
| Conditions and maintenance of drainage channels | 5.62    | 1       | 8       |
| Drainage channels quality               | 5.27    | 1       | 8       |
| **Total**                               | **64.83**| **32.50**| **80.00**|

Yield falls with land degradation, irrespective of whether fertilizer is being applied or not [10]. Farmers were already aware of the condition of farming land that still had many rocks with a high threat of soil erosion. Farmers had tried to protect their land by making terraces. The terraces making were done by adjusting the conditions of the land. Looking at the item score, it appears that farmers prioritize terraces as a means of preventing landslides compared to drainage channels.
Table 6. Score of agronomic sustainability category on maize farming in dry lands in Grobogan District in 2016.

|                                      | Average | Minimum | Maximum |
|--------------------------------------|---------|---------|---------|
| Planting Index                       | 7.44    | 7       | 8       |
| Seed embroidering                    | 2.78    | 1       | 6       |
| The accuracy of the application of organic fertilizer | 4.24    | 1       | 9       |
| Use of organic pesticides            | 1.58    | 1       | 2       |
| Plant protection                     | 1.96    | 1       | 5       |
| Waste utilization                    | 2.11    | 1       | 8       |
| Accuracy of crop rotation            | 8.00    | 8       | 8       |
| Livestock population                 | 4.20    | 2       | 6       |
| Management practices in the livestock sector | 4.04    | 1       | 9       |
| **Total**                            | **40.40**| **27.78**| **53.33**|

In maize farming, crop protection efforts are classified as minimal and rarely use organic pesticides. Farmers in Grobogan District rarely raise livestock so that the utilization of livestock waste is still minimal which in turn affects to the low productivity of maize. In the next, it necessary to enhancing maize tolerance to drought and heat waves, summarizing the elite shoot and root traits and phenotypes, and proposing ideas for sustainable production in changing climate [11].

The initial step to calculate the Total Sustainability Index is by asking farmers to rank the four categories based on the priorities that have been carried out.

Table 7. Total sustainability index on dry lands Farming in Grobogan District in 2016

| Sustainability       | Rank | Partial Sustainability index | Weight | Average | Minimum | Maximum |
|----------------------|------|------------------------------|--------|---------|---------|---------|
| Economic             | 3    |                              | 22.68  | 10.18   | 3.62    | 18.91   |
| Social               | 2    |                              | 23.00  | 10.42   | 6.50    | 18.42   |
| Land                 | 1    |                              | 33.43  | 21.91   | 6.09    | 30.39   |
| Agronomic            | 4    |                              | 20.88  | 8.64    | 3.98    | 14.00   |
| Total Sustainability Index | 5    |                              | 51.15  | 20.19   | 81.73   |

It can be seen from the table that the order of priority of farmers is land sustainability, social, economic and agronomic. To find out the Partial Sustainability Index is by multiplying the score of each item with the criteria weight. It can be known that the average of the Total Sustainability Index of farmers who cultivate maize farming in Grobogan District is 51.15% (category 3, refer as moderate).

Table 7 shows that 20.19% of farmers have a low level of sustainability. There is an opportunity of 75.9% to increase the sustainability score especially on economic and agronomic items so that it will be the same as farmers with a high level of sustainability (81.73%).
The results of the study are not in line with [6] where the important conclusion from the analysis of SFSI is that small farms, large-scale and high intensity farms can be not only economically viable, but also environmentally friendly, and in general, highly sustainable if properly managed.

3.3. Formulating Alternatives Efforts to Improve the Sustainability of Maize Farming

The government needs to make serious efforts so that maize production can meet domestic needs. China’s rapidly growing innovation capabilities and dynamic pattern of development also offer a unique opportunity for more sustainable and responsive agri-food systems [12].

In line with the research [10], intervention is called for to arrest further damage to physical soil properties and avoid further depletion of soil nutrients.

To get a more detailed picture and alternative solutions that can be taken are done by digging up information from relevant agencies through the Focus Group Discussion forum. In summary, SWOT identification is as follows:

**Figure 1.** Sustainability of maize farming in dry lands in Grobogan District in 2016
Table 8. SWOT Analysis

| Strengths                  | Weaknesses                                         |
|----------------------------|-----------------------------------------------------|
| 1. Experienced family      | 1. Quality of farmers                               |
| 2. Easy cultivation        | 2. Narrow land and poor quality                    |
| 3. Commercial orientation  | 3. Low capital and difficult marketing              |
|                            | 4. Conservation facilities are still simple         |

| Weaknesses                 | Opportunities                                      |
|----------------------------|----------------------------------------------------|
| 1. Quality of farmers      | 1. Subsidies for the price of inputs               |
| 2. Narrow land and poor    | 1. Facilitation of land conservation infrastructure |
|   quality                  | 2. Warehouse receipt policy                        |

| Opportunities              | Threats                                            |
|----------------------------|----------------------------------------------------|
| 1. Government support      | 1. Compete with imported maize and other commodi-  |
|                            | tities.                                           |
| 2. Broad market            | 2. Weather, climate                               |
| 3. Farmer groups, training|                                                    |

| Threats                    | Opportunities                                      |
|----------------------------|----------------------------------------------------|
| 1. Compete with imported   | 1. Facilitation of land conservation infrastructure |
|   maize and other          | 2. Warehouse receipt policy                        |
|   commodities.             |                                                    |
|                            |                                                    |
| 2. Weather, climate        |                                                    |

From SWOT analysis, there are four possible alternative efforts which might be taken to improve the sustainability of maize farming. Those are:

a. Subsidies for the price of inputs

The experience of farmers who have been working on maize farming for a long time needs to be supported by government policies, especially subsidizing the prices of seeds and fertilizers, as well as expanding harvested land by optimizing PERHUTANI land.

b. Facilitation of land conservation infrastructure

The type of land at the study area is dry land and some are at a high slope. Some conservation efforts that have been carried out independently by farmers are in the form of terraces, drainage channels and reinforcement plants. The main obstacle is the availability of water, and the solution that can be done is through the creation of ponds that require large expertise and funds. For this reason, government facilitation is needed.

c. Warehouse receipt policy

The high demand for maize has not provided market guarantees and fair prices for farmers. This is due to the weak bargaining position of farmers. For this reason, government facilitation is needed in the form of warehouse receipt policy.

d. Optimizing the function of farmer groups

Farmer groups play an important role as a forum to improve information, knowledge and skills of farmers related to cultivation technology, input prices and market opportunities, so that optimizing farmer groups is expected to improve the competitiveness of maize from research areas in the market.

The suggested strategies are in line with previous research conducted by Tiwari et al. [13] that to ensure environmentally and socially sustainable production, government policy and programs should be recommended locally available for vegetable production and support market mechanisms which can be competitive in national and international markets.

4. Conclusions

The results showed that farmers tried to increase production by applying "siti methuk" cultivation technique, where farmers began planting again even though the maize had not been harvested. Many constraints faced by dry land maize farmers in Grobogan District are related to land, labour, capital and marketing. With its limitations, farmers continue to strive so that maize farming remains sustainable with a priority sequence of aspects of land, social, economic and technical cultivation. The average score of sustainability analysis with The Synthetic Farm Sustainability Index of Majewski is 51.15, the
alternative sustainable improvement of maize farming that can be conducted are subsidies for the price of inputs, facilitation of land conservation infrastructure with deep wells, attractive output prices with warehouse receipt policy, and optimizing the function of farmer groups.

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