Strategy of sago management sustainability to support food security in Regency of Meranti Islands, Riau Province, Indonesia

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Abstract. Sago (*Metroxylon* sp.) is an alternative food source for people in Regency of Meranti Islands of which existence can support food stability for this region. Area of *Metroxylon* sp. in 2017 in Regency of Meranti Islands was ± 53.456 ha. In order to encourage sago development to support food security, a sustainable management system is required. Those efforts are expected to realize the optimization of production and improve the processing efficiency and could increase economic value for the community. The purpose of this research is to analyze sustainability of sago management (through assessment of sustainability index and status) in supporting food security. The assessment of sustainability index and status of sago was measured by Rap-Sago method using Multi-dimensional Scaling (MDS) which was then validated by Monte Carlo analysis. The result of the Rap-Sago ordination technique using MDS indicates that the sago management index score is in the range of 32.35–46.85 (unsustainable status). From the five dimensions with 73 assessed attributes, there are 21 attributes that are the leverage factor for sago management's sustainability in supporting food security. The socio-cultural dimension with index score of 46.85 has three leverage factors: the rate of employment, the percentage of the poor and the level of formal education of the community. The economic dimension with index score of 36.57 has five leverage factors: the type of exported products, the Ijon system, the business licensing system, the capital access opportunity and the capital capability of the farming business. The environmental /ecological dimension with a score of 32.35 has five leverage factors: the area of sago land, water management, soil type, vegetation associations and hydrology. The technology dimension with index score of 44.85 has three leverage factors: yield processing technology, waste treatment technology and nursery technology. While the institutional dimension with index score of 45.42 has four leverage factors of levers: farming group, sago farmers association, access of farmers group to banking and government policy.

Key Words: Multi-dimensional Scaling (MDS), Rapid Assessment Techniques (RAP), attribute, Monte Carlo analysis, leverage.

Introduction. Food is one of the basic needs of the population which its quantity, quality and continuity must be available at all the time. Food demand is expected to grow as the population increases. If food demand is far greater than the availability of food, it will increase the chances of food crisis and cause food security problems (Ruhukail 2012). Sago is one of the food crops that have the potential to be developed and used in Indonesia to support food security (Kusuma et al 2013). Rice as staple food has been consumed by 95% of Indonesian population (Wardis 2014). Current rice consumption reaches 97.23 kg/capita/year (BPS 2014). Consumption of rice is expected to increase as the population grows by 1.49% annually (BPS 2011) and leads to a rice deficit when eventually Indonesia must import the rice. According to BPS (2017) in 2000-2015 Indonesia continues to import rice between 250 thousand to 4.7 million tons, and in 2015 Indonesia imported 861,601 tons of rice. As stated in Law No. 7 of 1996 on food,

Indonesia has a high commitment in terms of food security. According to the law, food security is defined as the condition of the availability of food in sufficient quantity and optimal quality, and it is safe, equitable, diverse and affordable. Strengthening of local food in supporting the development of national food security and independency is important, thus optimizing the use of alternative food which in some areas has become local food and a culture in society becomes a necessity (Alfons & Rivai 2011).

The potential of sago plants owned by Indonesia is very high. Indonesia has the widest sago crop area in the world with 5.5 million ha sago field (Bintoro et al 2016). The majority of sago areas are in the form of sago forests situated in Papua and West Papua with dry starch productivity between 83-372 kg per tree (Ahmad et al 2016; Dewi et al 2016). In the western part of Indonesia especially in the Regency of Meranti Islands sago (*Metroxylon* sp.) is a plant that has been cultivated and consumed for a long time and become the main source of income for most people in the Regency of Meranti Islands. The production of sago in Regency of Meranti Island per year reached 200,062 tons (BPS 2014) and became the largest sago producer in Indonesia by supplying 36% of national sago needs (Ahmad 2014). Regency of Meranti Islands is not only produces sago starch, but has produced 369 processed foods from sago that get MURI record (Museum Record Indonesia). Sago has various derivative products including liquid sugar, bioethanol, animal feed, pharmaceutical and environmental-friendly plastics (Bujang 2011; Bukhori et al 2017; Tiro et al 2018; Oladzadabbasabadi et al 2017; Zawawi et al 2017).

The present research intended to re-empower the role of sago as a source of local food that has not been optimized yet. Utilization of local resources optimally is one of the strategic steps to achieve sago business efficiency and increase the economic value gained by the sago farmer's community in the Regency of Meranti Islands. Sustainable sago management in this research using five dimensions: ecological dimension, social and cultural dimension, economic dimension, technology dimension and institutional dimension.

Material and Method

Research Location. The study was conducted from April to October 2017. The research location was in Regency of Meranti Islands, Riau Province (Figure 1). The research location was determined purposively, namely Regency of Meranti Island as one of the sago cultivation center (not natural sago) that the farmer had set the crop spacing of 10 x 10 m, thinned the sapling and did the harvesting before the flower initiation phase.

Data collection method. The initial phase of this research began with data collection at several locations of sago management in Regency of Meranti Islands. In obtaining the required information, the methods used in research were as follows:

- Observation. Researchers conducted direct observation in the field to collect data about the condition of sago management object in the research location.
- Deep interview. Stakeholders are institutions that play a role in sago management and development. Stakeholders who play a role included government, businessman, sago farmers, financial institutions, academics, and non-governmental organizations (NGOs). Selection of respondents was based on their surrounding environmental conditions and their understanding about the problems studied. Today the method or way of digging information and knowledge or expert opinion in this research was using expert survey method which was divided into 2 (two) ways, including:
  a. Respondent from experts
     Expert respondents were purposively chosen (purposive sampling) with the criteria of having expertise in accordance with the field being studied. Some considerations in determining the experts to be respondents are:
     • Have a competent experience according to the field being studied;
     • Have a reputation, position in its competence with the field being studied;
     • Have a high credibility, be willing, and be in the location studied.
  b. Respondents from the community at the study sites used purposive sampling method (Walpole et al 1995).

- Focus Group Discussion (FGD). FGD is a common method of data collection used in social qualitative research. This method relies on the result of data or information from an interaction of respondents based on the results of discussion in a group that focuses on discussing in solving certain problems. In the FGD on sago management, the stakeholders who play a role included government, businessmen, sago farmers, financial institutions, academics, and NGOs, in detail are presented in Table 2. The research on sago management and development did the World Cafe Method (WCM) or Focus Group Discussion (FGD) which aimed to obtain inputs and opinions on the management and development of sago. Details are presented in Table 1.

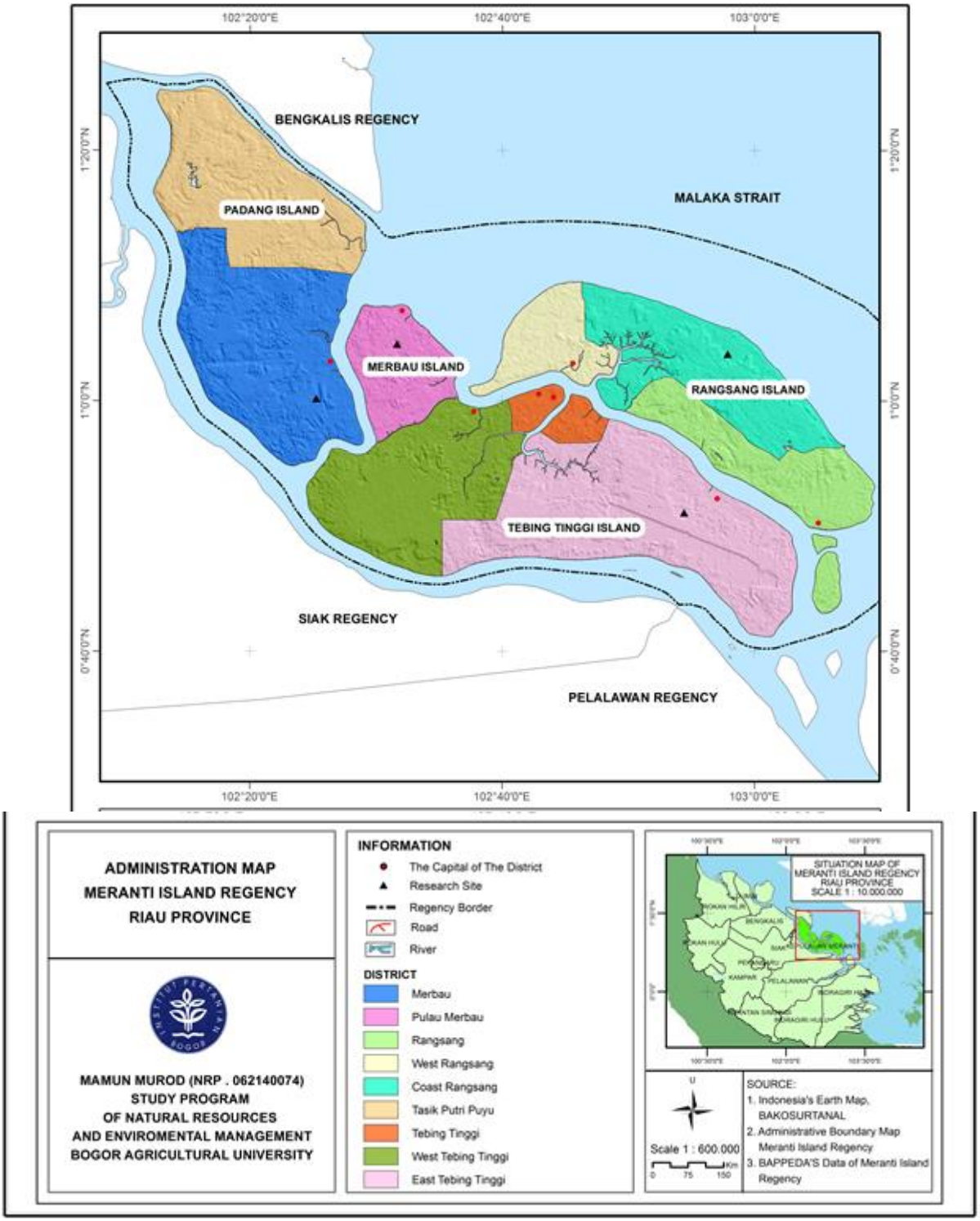

Figure 1. The location of sago (*Metroxylon* sp.) management research.

Table 1

The stakeholders quantum within Focus Group Discussion (FGD) of sago management

No	*Stakeholders*	*Total*	*Description*
1	Government	18 individuals	Head of village (4 persons), head of district (4 persons), the regional development planning board (Bappeda) (4 persons), Industry and Trade Department, Plantation and horticulture Department, Forestry and Environment Department, Crops Department, Agriculture and Livestock Department and Fishery Department
2	Businessmen	4 individuals	Sago Management Industry (2 persons) and Harmony Cooperative (2 persons)
3	Sago farmers	4 individuals	East Tebing Tinggi district (1 person), coastal Rangsang district (1 person), Merbau Island district (1) person), Merbau district (1 person)
4	Financial institutions	2 individuals	BRI and BNI Banks
5	Academics	1 individual	Riau University (UNRI)
6	Non-governmental organization (NGO)	1 individual	Living environment facility (Walhi)

Data analysis method. The analysis of sustainability index and status of sago management was done by RapSago (Rapid Assessment Techniques for Sago) modified from RAPFISH (Rapid Assessment Techniques for Fisheries) developed by Fisheries Center, University of British Columbia, Canada (Kavanagh & Pitcher 2004). RapSago analysis was done through several stages. First thing was determination of sago management attributes covering five dimensions (ecology dimension, social and cultural dimension, economic dimension, technology dimension and institutional dimension). Second step was the assessment of attributes by ordinal scale according to the criteria of sustainability of each dimension. Third step was ordination analysis to determine the value of ordination and stress. Fourth step was determination of sustainability index and status of sago management. Fifth step was sensitivity analysis (Leverage Analysis) in order to see sensitive attributes that affected the sustainability and the sixth step was the Monte Carlo analysis to measure the uncertainty. The Multi-Dimensional Scaling (MDS) method could cover a wide range of factors related to the sago dimension by determining the two points being the reference which is good and bad. This method is basically a multivariate method which is also known as one of ordination in reduced space. Ordination itself is a process of plotting the point of an object (position) along the axes arranged according to an ordered relationship or in a graphic system consisting of two or more graphics. The advantage of this method is that it could summarize the multidisciplinary data obtained from the field thus it could produce a lot of information quantitatively. Approaches to this method have been widely developed to analyze various issues including local economic development (Budiharsono 2017), fishery resources (Fauzi & Anna 2005), land use (Widiatmaka et al 2015), consumer perceptions (Masuku et al 2014) and wet land conversion (Firmansyah 2016). The detailed steps are presented in Figure 2 modified by (Budiharsono & Firmansyah 2016) from (Alder et al 2000) with a general description below:

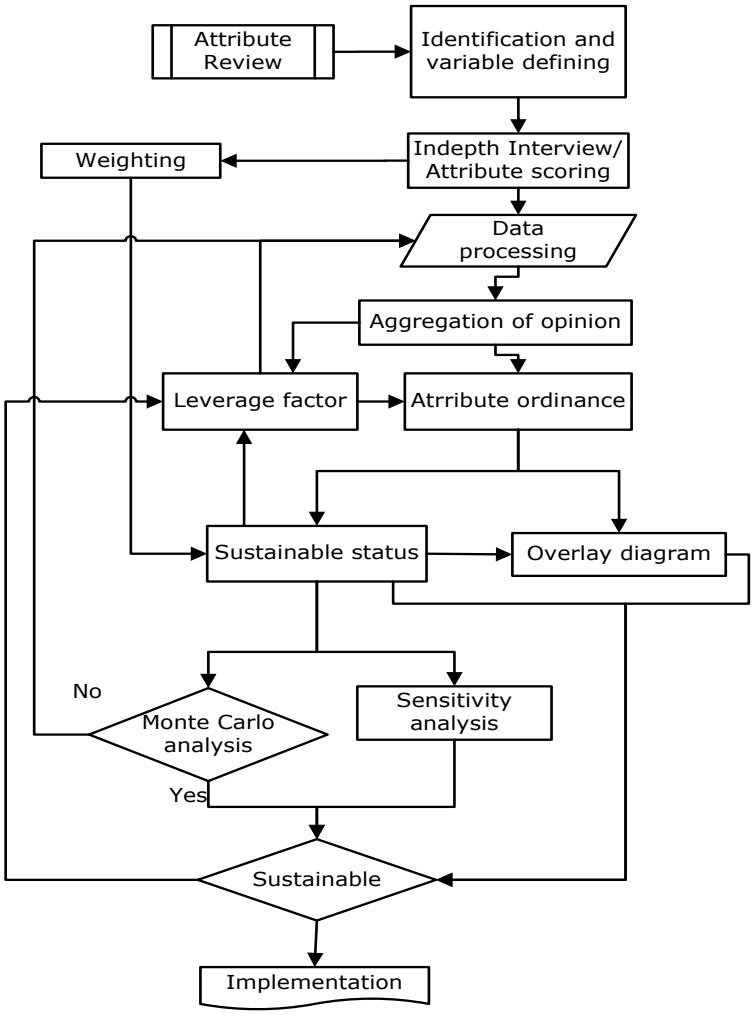

Figure 2. Analysis stages of multidimensional scaling (Budiharsono & Firmansyah 2016).

- The determination of dimensions and attributes was based on literature studies and expert discussions to define and scale the assessment;
- Data obtained from real opinions and conditions in the study area were weighted (pairwise-comparison) based on the scale of importance according to (Saaty 1993) for comparison between dimensions and scoring values for each variable / attribute;
- Determinationof the main reference: good (good) and not good (bad) by doing a good score and not good at all the variables/attributes;
- Made two other major points of "midpoint" which is a bad point and a good point. These two additional main reference points serve as vertical referrals ("up" and "down");
- Created an additional reference point called anchors that can be used to help the ordination outcomes. The point is as the stabilizer acting points that form a control loop so that the status value points are not at outside of it. These points are also useful in performing regression analysis to calculate the "stress" which is part of MDS.
- Standardized score values for each attribute by method:

$$X_{ik}\,sd = \frac{X_{ik} - X_k}{S_k}$$

$X_{ik\ Sd}$ =standard score value (including its reference points) to i = 1, 2,...n, at every attribute to k = 1,2, ... p;

X_{ik} =initial score value of research location (including its reference point) to i = 1,2,..., n at every attribute to k = 1,2, ..., p;

X_k = score middle value of each attribute *k = 1, 2,..., p;*

Sk = standard deviation score of each attriute to *k = 1, 2,..., p.*

K = attribute

- Calculated the distance between positions using n-dimensional Euclideon Distance method (Kavanagh & Pitcher 2004) written as follows:

$$D^2(ij) = \Sigma(X_{ik} - X_{jk})^2$$

- Created ordination for all attributes for each dimension based on algorithm aspect analysis of multidimensional scaling. In the MDS analysis, the attribute dimension that was originally a lot, became only two dimensions that will be the X and Y axes. The result of ordination is the V matrix (n x 2) where n is the number of locations studied.
- The distance between objects were calculated by using the Euclidean distance regression (dij) with the origin equation (dij) could be written as follows:

$$d_{ij} = \alpha + \beta\delta_{ij} + \varepsilon$$

- Regression analysis in MDS included stress assessment by doing Goodness of fit in MDS became very important because Goodness of fit reflects the indicator of S value (stress> 0.25). For the sustainability of "Not Good" to "Good" (0 to 100) on the upper x axis is +50 on the axis -y scale and the bottom is -50 on the axis -y scale that refers to i = 1, 2,....n;

$$Vf(i,1) = 100 \left[\frac{V(i,1) - V(I\,bad,1)}{V(I\,up,2) - V(I\,down,2)}\right]$$

$$Vf(i,2) = 100 \left[\frac{V(i,2) - V(I\,down,2)}{V(I\,up,2) - V(Idown,2)}\right] - 50$$

The result: Vf (i,2) = Vf (i,2)- Vf(I good,2)

This sensitivity analysis was performed using "attribute leveraging" to see the change of MDS analysis results. The effect of each attribute was seen. If the index value ≥50 then the aspect or dimension of the existence of the wetland was good and vice versa, if the index value <50, then the aspect or dimension was not sustainable. After MDS analysis is obtained in the form of root mean square (RMS), especially on the x axis on the sustainability scale, resources and changes on y-axis changes were not taken into account, this is because only to see the RMS changes. The RMS formula is:

$$RMS = \sqrt{\left(\frac{\sum_{i=1}^{n}\{Vf(i,1) - Vf(.,1)\}^2}{n}\right)}$$

Vf (i1) = the value of MDS score (half rotation and flfing)
Vf(.,1) = the value of middle MDS result on the first coloum to 1

The sustainability index scale has 0-100% interval. If the system is indexed >50% then the functions are sustainable, and vice versa if is <50% then the system is not sustainable. In the present research, the authors divided in 4 categories the sustainability status based on the basic scale (Table 2).

Table 2

The status of sago sustainable category

Index Value	*Category*
0 - <25	Not sustainable
25 > Index < 50	Less sustainable
50 > Index < 75	Quite sustainable
75 > Index < 100	Sustainable

Result and Discussion. Based on the results of the analysis of sustainability, it was seen that the management of sago is still not optimal. This described the sustainability status of sago management and various important factors that exist in the Regency of Meranti Islands which were still not sustainable yet. Thus it needed an effort to improve on some variables that become the leverage factor of each dimension. In this study, we will look at the levers factor and sustainability status in five dimensions.

Ecology dimension. Assessment of ecological dimension sustainability status was performed on 14 attributes. The result of MDS analysis for ecological or environmental dimension sustainability status was 32.35 or classified as less sustainable criteria. Of the 14 attributes, the 5 highest attributes were: (1) Sago land area (5.67 points), (2) Water management (4.28), (3) Soil type (4.19 points), (4) Vegetation associations (4.03 points) and (5) Hydrology (3.78 points). The result of MDS analysis for ecological or environmental dimension sustainability status is 32.35 classified as less sustainable criteria. The sustainability status of the ecological dimension is presented in Figure 3.

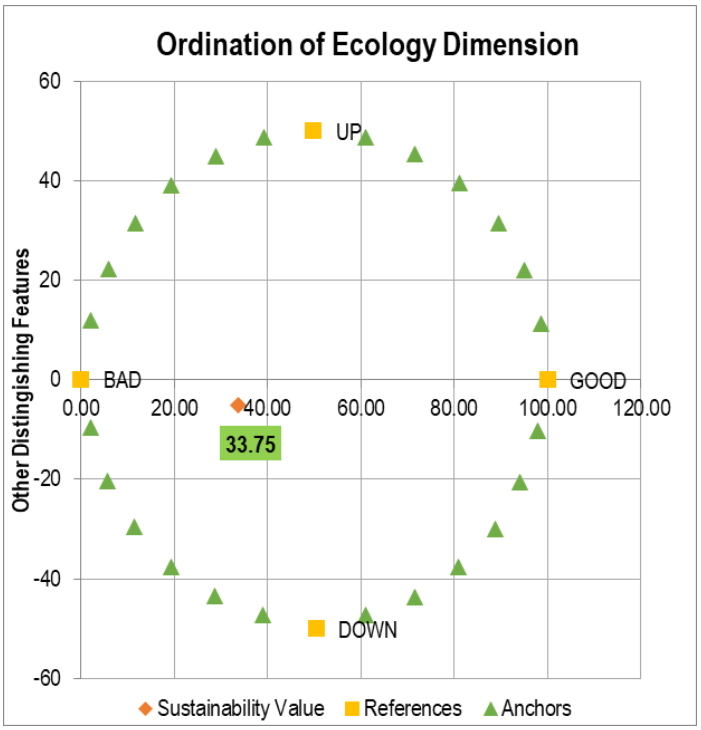

Figure 3. Status of sustainable ecology dimension.

The first leverage factor affecting the ecological dimension was the area of sago land. Sago farmers in Regency of Meranti Island have an average of 7 lanes (2 ha) of sago palm. Sago is ready to be harvested from 10 years to 15 years (Chew et al 1999). Then every 1.5 years farmers can cut 100 sago trees for each hectare (Bintoro et al 2010). Each stem of sago produces an average of 9 parts or local people called it tual (each tual has 106 cm length) or produce 900 tual ha^{-1}. If the price per tual is 2.05 USD, then in one ha for every 1.5 years it can generate 1846.87 USD. Thus, the wider land ownership of sago will certainly provide enough welfare for farmers, but having 4 ha could guarantee the education of 1 child to remain in school up to university. Large land area will be directly proportional to the economic level of sago farmers. If sago farmers use machines to produce sago starch with narrow sago field, then the use of machine will not be efficient. During harvest time, sago tree couldn't be harvested in the same clump every year because the interval of harvest age between the parent tree and sago seedlings is considerable. According to (Jong 2006) in a sago grove there are 6-8 saplings of different ages. According to (Bintoro et al 2010) in a clump of sago kept 1

sapling every year, so that in the clumps can be harvested every year. Thus, the farmers are able to produce the harvest of sustainability and earn income every year.

The second leverage factor was water management. Water is a major requirement for sago plant growth so it needs good water management. The current effort is to build blocking canals that regulate the availability of water and not be released into the sea so water is always available. Blocking channels also serves as a filter so that sea water does not enter and the condition of the land remains wet. This can be a strategic effort in preventing fires.

The third leverage factor is the soil type. Based on the knowledge of sago farmers, there are three types of sago plantation habitat, namely, peat, mineral soil and clay in Regency of Meranti Islands (Rahayu et al 2013). According to local communities the above habitat types (peat, mineral soil, and clay) play a role in determining sago diversity and productivity. Sago crops in mineral soil habitat have higher productivity compared to clay and peat habitats.

The fourth factor is the vegetation association. Based on observations in the field, sago plantation was associated with tree plants, herbs and undergrowth. The trees that often found and associated with sago were Alexandrian laurel (*Calophyllum inophyllum*), Tualang (*Koompassia excelsa*) and *Jackia ornata*, while the herbs associated with sago included Banana forest (*Musa* sp.), sea hibiscus (*Hibiscus tiliaceus*) and Gelam air (*Melaleuca leucandendra*) and undergrowth that associated with sago included water fern (*Ceratopteris richardii*), dasheen (*Colocasia* sp.) and climbing fern (*Stenochlaena palustris*) (Louhenapessy et al 2010).

The fifth leverage factor is hydrology. The growth and production of sago is strongly influenced by soil hydrology (Louhenapessy et al 2010). The class of hydrology can be divided into 5 classes: good hydrology (inundation less than 3 months), well hydrology (inundation between 3-6 months), moderate hydrology (6 - 9 month inundation), poorly hydrological (pools 9-12 months) and poor hydrology (inundation more than 12 months). Factors on the ecological dimension are presented in Figure 4.

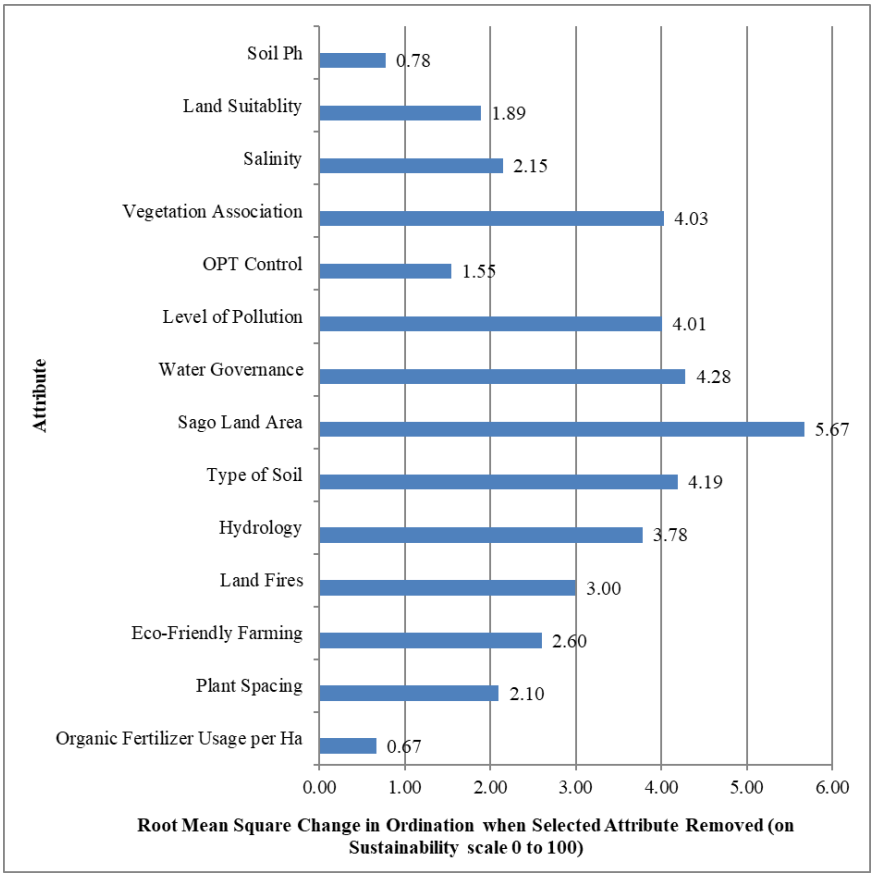

Figure 4. Leverage factors of ecology dimension.

Economic dimension. Assessment of the sustainability status of the economic dimension was carried out on 20 attributes. The score results of the analysis for the sustainability status of economic dimension was 36.57 or enter the category less sustainable. From the 20 attributes assessed, five factors that most influence the sustainability of the economic dimension in sago management in Regency of Meranti Islands are: (1) Types of exported products (2.63 points), (2) Ijon system (2.58 points), (3) Licensing system for plantation business (2.46 points), (4) capital access opportunity, and (5) capital investment capability (2.18 points). The sustainability status of this dimension is shown in Figure 5.

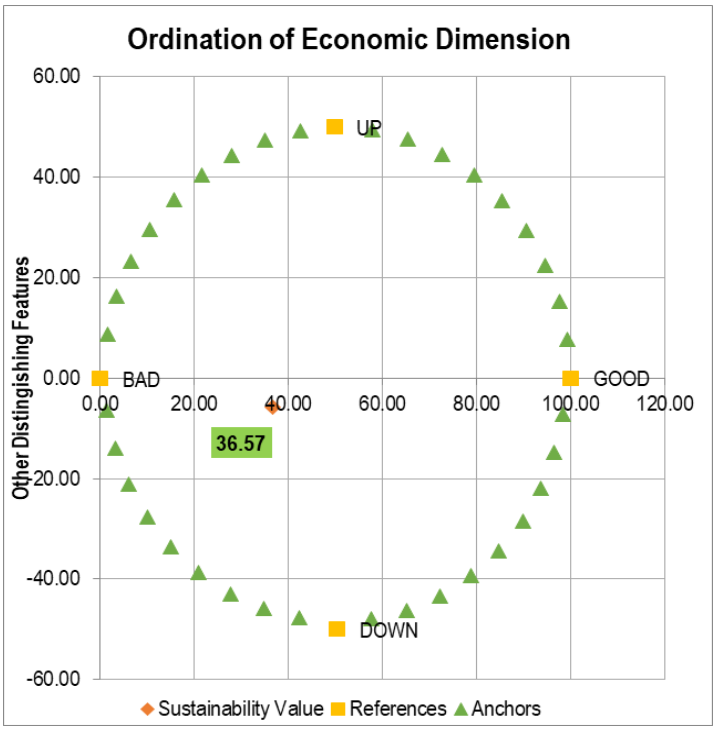

Figure 5. Status of sustainable economy dimension.

An important factor in improving sago management is the type of exported products. Demand for sago starch in addition to domestic consumption also has the potential to become an export commodity. Overseas market demand for sago from Indonesia is quite large. Currently, type of exported products are still in type of raw materials (sago starch) to Japan and Malaysia by companies and community cooperatives. Diversification of sago products into alternative processed food products could become sago's superiority in the future. This aspect certainly needs to get support and policy of the central and local governments in regard sago as a local food both in terms of availability, qualified and qualified processed products that can be exported as processed foods. The types of sago products exported in forms of starch are highly vulnerable if the availability of sago starch is low, so it is likely to be replaced by other starch sources. The availability of sustainable starch should be developed by the government such as improved cultivation techniques. Cultivation techniques supported by the government like other commodities will greatly help the process of product marketing.

The second leverage factor is the Ijon system. Ijon system itself is farmers selling/mortgaging sago crops that have not been ripe for a very low price. This is based on the basic needs of farmers must be met while the harvesting age is relatively long (>9 years). Another aspect that causes the Ijon system to grow in the community is the unavailability of employment in the village and unavailability of microfinance institution that easily and quickly handle the business of sago farmers. According to Partadireja (2006), there are several reasons why banks couldn't meet the needs of many rural people. That is because the general public does not have the legality of ownership of land

or assets to be pledged to the bank. There is a need for economic activities that enter the community such as activities intercropping sago plants with horticultural crops.

The third leverage factor is the capital access opportunity. Limited access to capital for sago farmers to financial institutions is due to the inability of the community to meet the requirements set by financial institutions providing the capital. It is therefore necessary to intervene from the government through deregulation/lending rules with easy and simple requirements. There are several community business in the village that could be developed into larger scales including processed sago-based products such as sago noodles (Harahap & Andry 2016). In addition, potential sectors that can be developed are Village Owned Enterprises (BUMDES) and cooperatives.

The fourth leverage factor is the capability of farming capital. Capital is one of the important factors for the sustainability of community sago management. The inability of farming capital owned by farmers resulted in the farmers to perform the Ijon system because the opportunity to access capital to financial institutions is still difficult to get by the community. So it could be seen that those three factors mentioned above were very closely related and couldn't be separated from each other.

The fifth lever factor is the licensing status of the plantation business. The granting of plantation business permit has been arranged by the Ministry of Agriculture by Regulation Number 98/Permentan/OT.140/9/2013 on Plantation Business License Guidance. Each plantation company must have a plantation business permit / plantation register for cultivation and plantation processing industry. Sago farmers in several villages in the Regency of Meranti Islands have land whose ownership and boundaries are unclear. If there are foreigners who want to buy the land then the farmers will sell it as an effort to meet the needs of life. The factors that make up the economic dimension are shown in Figure 6.

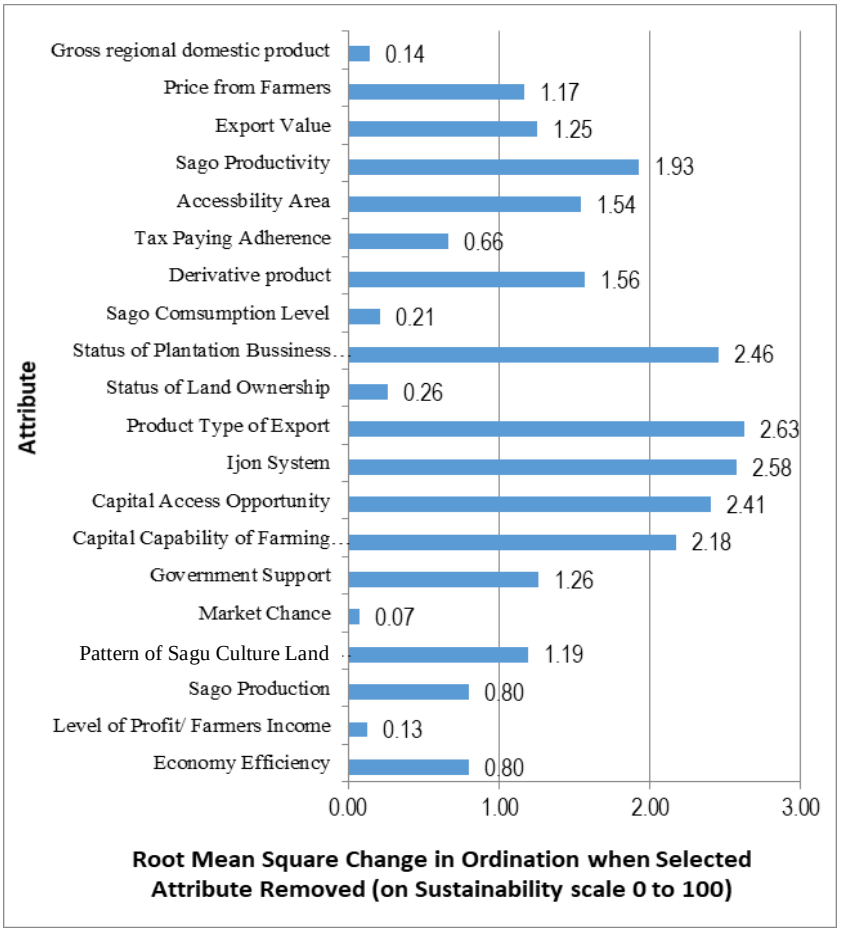

Figure 6. Leverage factor of economy dimension.

Social and cultural dimension. Assessment of sustainability status of socio-cultural dimension was carried out on 14 attributes. The result of analysis of sustainability status of social and cultural dimension was classified as less sustainable criteria with score of 46.85. From 14 attributes assessed, the three most important attributes based on the attribute values were: (1) Employment rate in sago management (3.36), (2) Percentage of population below poverty line (1.64), and (3) Level of formal education in the community (1.48). The sustainability status of the social dimension is shown in Figure 7.

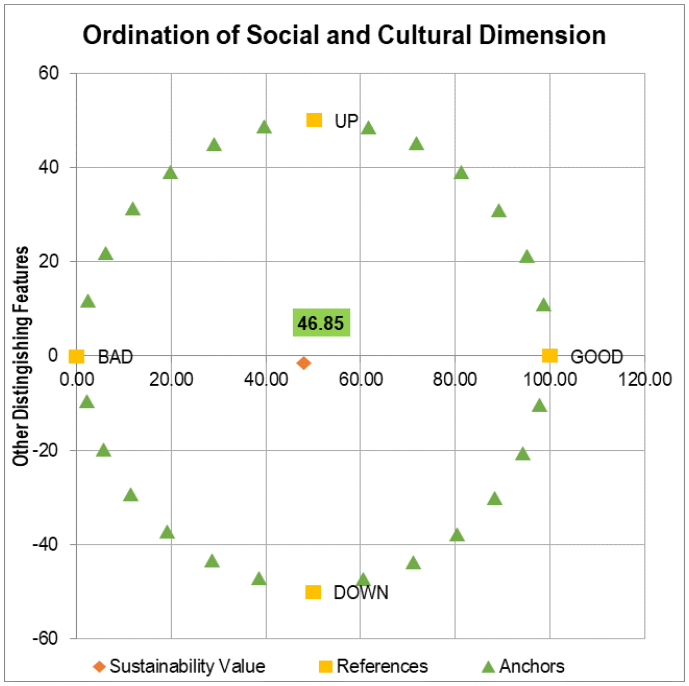

Figure 7. Sustainable status of social and cultural dimension.

From the social and cultural aspects, this three factors that have the highest value was really need to be noticed because it determines the sustainability in the management of sago in the future. As we know the Regency of Meranti Islands is a national food security development area. This is because the region is the largest producer of sago commodity in Indonesia. Sago production in Regency of Meranti Islands has the potential to improve the economic condition. However, this has not been fully realized due to the constraints of the employment in the field of sago management. The low employment rate in the management of sago, one of which is caused by the Ijon system in smallholder sago plantation. Ijon system is done by the sago plantation owners to the middlemen or sago collectors with the sale of sago in a state which is not yet in time of harvest. The sago planters choose Ijon system because sago land has become the only one support of people's life in fulfilling they necessities. When the people has urgent needs and sago is not ready for harvest yet then the community performs Ijon system. In the long run it will be detrimental to sago farmers because farmers couldn't develop sago independently and sago plantations have been bound by middlemen. The lack of sago development in the community by the owner has an impact on the management of sago from the plantation until postharvest thus the labor couldn't be absorbed. In addition, the labor in the sago plantation is mostly rough labor such as cutting trees, cutting tual and pulling tual.

According to (Sholeh 2007) that employment matters become top priority for local and central government as the one of development targets. Stages of economic development of a country is closely related to the existing industrialization in the country, where the process of economic development and industrial development as an effort to improve the welfare of society and can improve the quality of life of the community. In 2015, the number of sago farmers in the Regency of Meranti Islands was 7,484 households

(Dishutbun 2016). The development of sago in Regency of Meranti Islands is still based on the provision of raw materials (sago starch) for industry, not yet in the industry itself. This causes that the community has not gained maximum benefits from the management of sago. In the future, the development of sago towards the industrialization can be implemented in the Regency of Meranti Islands thus it can embrace the job opening for the community. Various factors on the social dimension are presented in Figure 8.

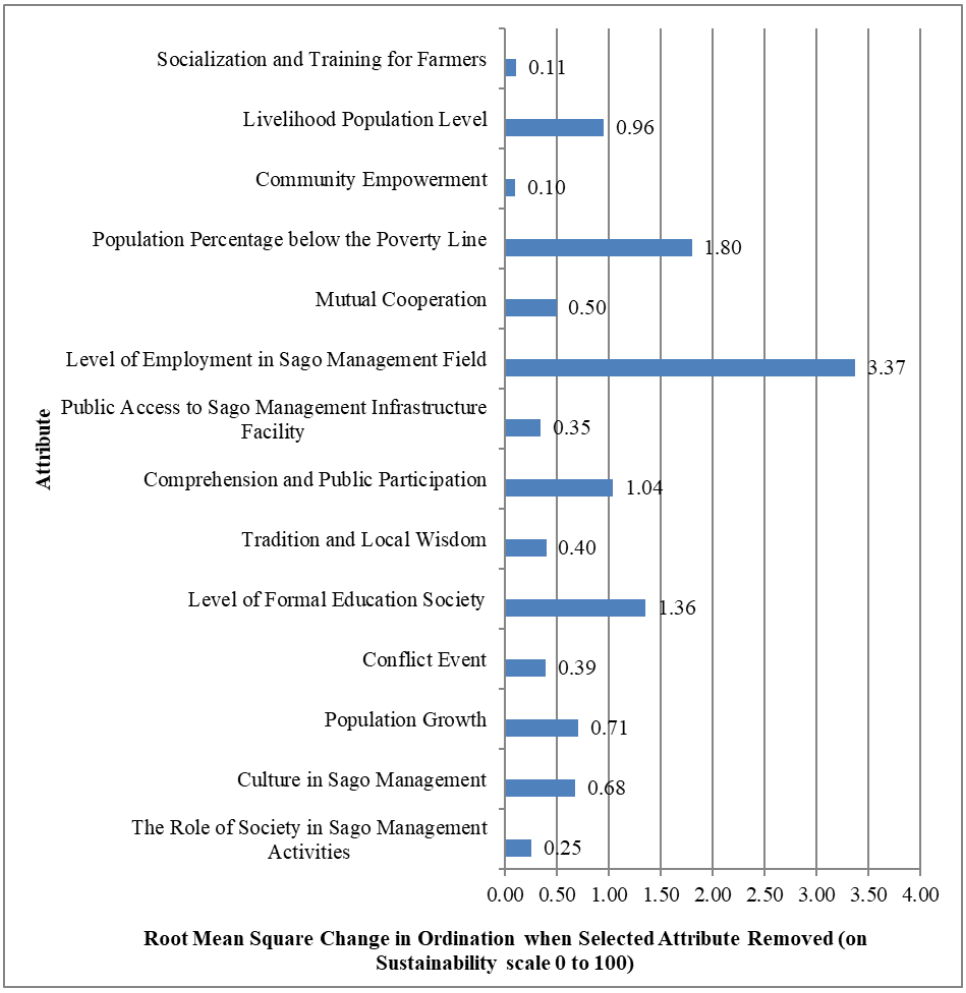

Figure 8. Leverage factor of social and cultural dimension.

The second leverage factor is the percentage of the population below the poverty line. The percentage of poor people in this regency is very high compared to other regencies in western Indonesia (Figure 9). Nowadays the number of poor people has declined from 61,640 in 2015 to 56,180 in 2016 (BPS 2016). The low percentage is due to the development of Ijon system in smallholder sago plantations. Ijon system caused a very low income for sago farmers. If the farmer sells one stalk of sago directly to the owner of sago refinery for 34.20–47.88 USD per stem, then the farmers who aply the Ijon system could only sold for 6.84–13.68 USD per stem. The low income of farmers from the sale of sago impacts on the fulfillment of low community needs, so that it's only enough to meet the needs of daily living. It is necessary to develop sago products to form a business that can add value to sago and sago farmers don't have to perform Ijon system (Harahap & Andry 2016).

The third leverage factor is the level of formal education in the community. Based on the educational variables in the Community Development Index (HDI) of Regency of Meranti Islands, in 2016 the average number of years of school of the people reached was 7.46 years and the expectation was 12.74 years (BPS 2017). This shows that the level of education has not reached the nine-year compulsory education level declared by the government. Improvements in the education sector are expected to provide greater opportunities for communities to earn a more decent living. In addition, due to the Ijon

system, sago farmers couldn't cultivate their sago plantation freely, which affects the demands of sago farmers to their children to continue the sago plantation business couldn't be implemented maximally. If the activities in the sago plantation are only cutting trees and pulling tual, then there is no need for high school to continue the business. That thought becomes a matter that needs to be changed that the management of sago gardens is not entirely rough work, but include the management of the plantation from planning to marketing of sago derivative products. The development of sago processed products also needs to be developed by the existing human resources in the village to increase the added value of the product (Purwanto et al 2017).

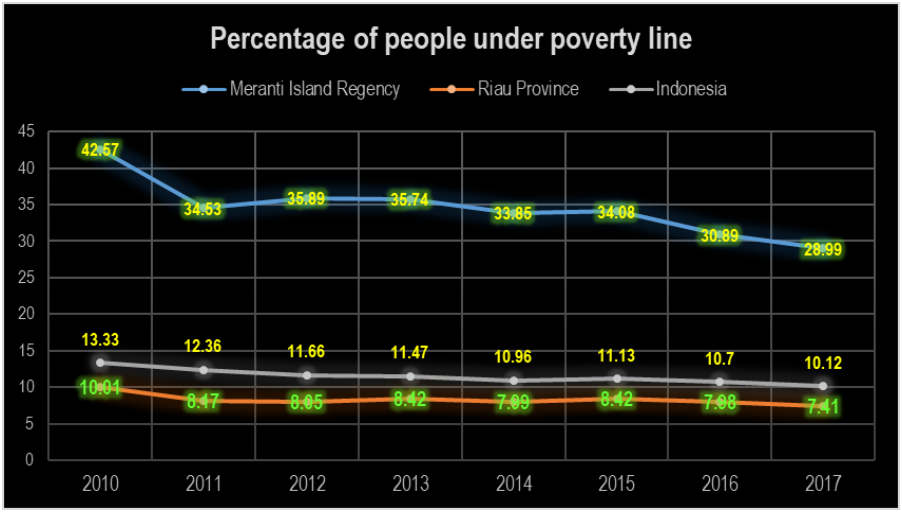

Figure 9. The poverty rate of Regency of Meranti Islands.

Technology dimension. Assessment of sustainability status of technological dimension was done on 14 variables. The results of MDS analysts for sustainability status dimensions of technology entered in the category less sustainable because it has a score of 44.85. From the 14 attributes, three most influential attributes of sago sustainability management in the Regency of Meranti Islands are: (1) yield processing technology (2.87 points), (2) waste treatment technology (2.76 points), and (3) nursery technology (2.58 points). The sustainability status in this technical dimension is shown in Figure 10.

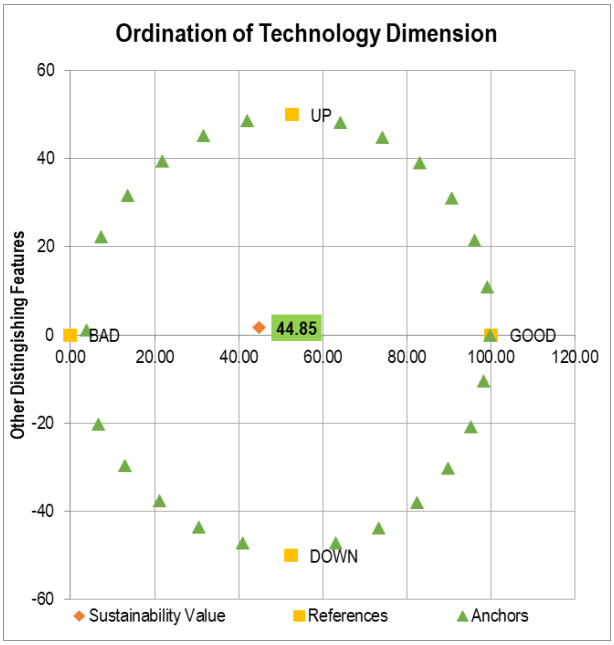

Figure 10. Sustainability status of the technology dimension.

The first leverage factor in the technological dimension is the yield processing technology with a value of 2.87. The yield processing technology is carried out for the efficiency and effectiveness of the product. Technology at the upstream is expected to increase the amount of sago yield obtained and with good quality, while technology at the downstream is expected to increase economic value in terms of diversification of processed products of sago. Society process sago yield in the form of wet starch. Wet starch will be easily damaged, not durable in storage and difficult in postharvest handling. Processing technology is needed to address such solutions such as starch drying when the weather is not supported.

The second leverage factor is waste management technology. Implementation of waste management technology that has not been implemented causes waste is still a problem for the environment. Waste management technology is expected to be able to manage the waste so the waste is no longer a problem but becomes an economic value and beneficial to the environment. One of the utilization of sago waste that has been done is as raw material for animal feed (Hariyanto et al 2016).

The third leverage factor is nursery technology. Nursery becomes very important when planting crops in wide scale. Good nursery will produce good seeds with a high percentage grow. Selection and handling sago seedlings that will be used as seed will affect the seeds produced. Some nursery technology has been done including the technique of growing crops from seeds (Ehara et al 1998), cutting roots and leaves of saplings to increase the percentage of life (Irawan et al 2011), making the best conditions of nursery and increasing the water level of the saplings to increase the percentage of life (Irawan et al 2011). Sago in Regency of Meranti Islands is a superior variety that Indonesia own. This is proved by the issuance of certificate of release of sago variety under the name Sagu Selatpanjang Meranti. With this in mind, it's expected that the sago development in the community is guaranteed to grow. The nursery technology is more focused on the Sago Selatpanjang Meranti variety in order to produce high quality of sago seeds. Factors on the technical dimensions are presented in Figure 11.

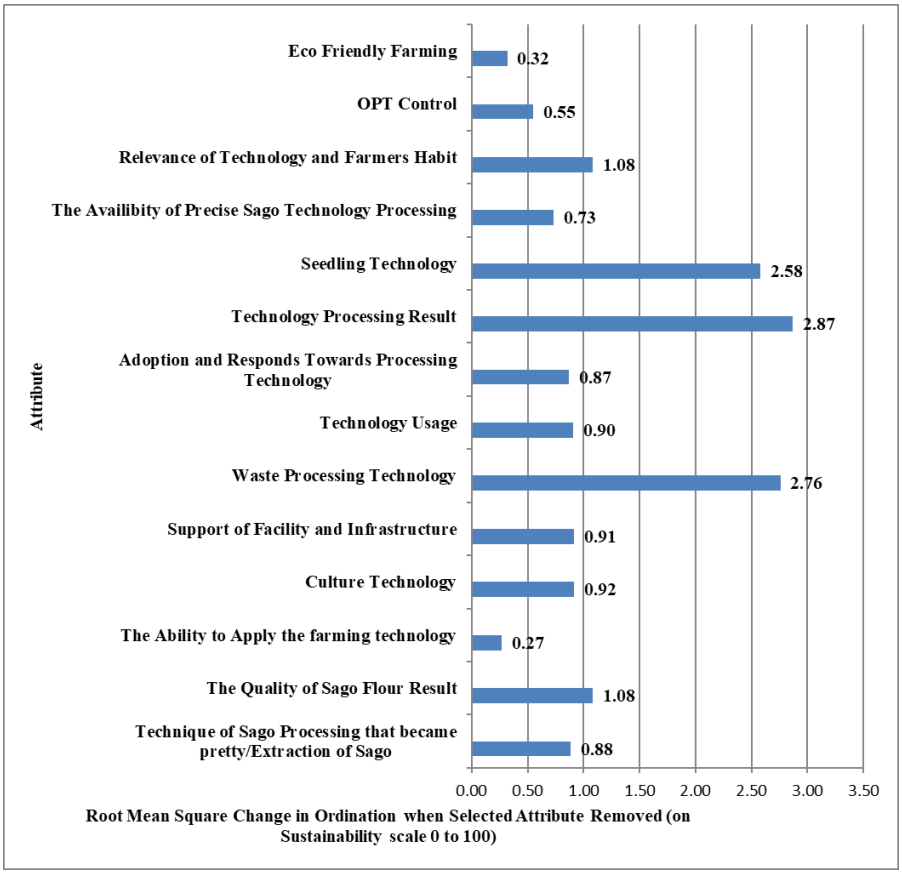

Figure 11. Leverage factors of technology dimension.

Institution dimension. Assessment of sustainability status on the institutional dimension was done on 11 attributes. Based on the assessment of the sustainability status of the institutional dimension using the MDS calculation, the institutional dimension was considered less sustainable with a value of 45.42. From the 11 attributes assessed, the five most influential attributes were: (1) Farming group (4.69 points), (2) Sago farmers association group (4.09 points), (3) Farmers' access to banking (3.64 points), (4) Government policy (3.60 points) and (5) Farmers' organization (Gapoktan)'s existence. Institutional dimension was less sustainable with value 45.42 (Figure 12).

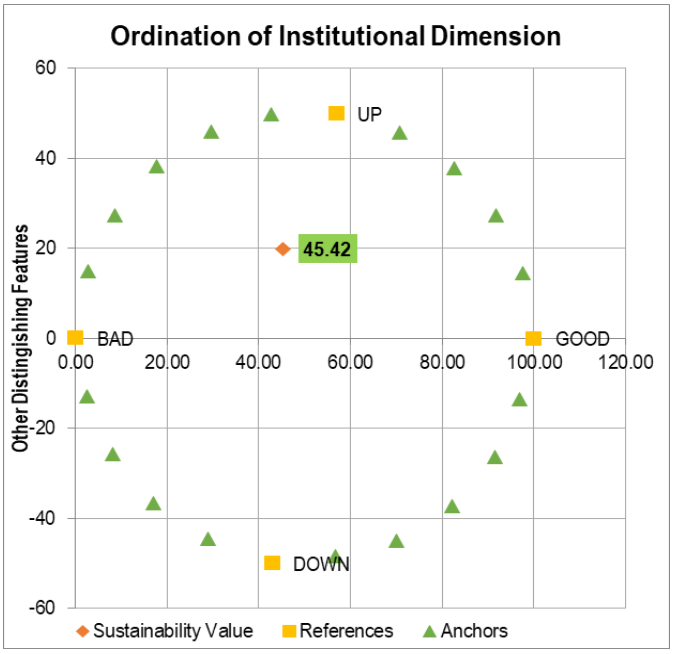

Figure 12. Suistanable status of institution dimension.

From the five attributes that exist, four attributes have the same relationship which is the existence of farming groups either in the form of sago farmers association or a farmers' organization. With the existence of sago farmers institution, the ease of assistance from banks or from the government can be obtained. Farmers' organizations with clear legal status ensures that the sago farmers within the organization receive legal protection/advocacy if they are involved in law matters. In addition to institution factors in farmer groups, the support of local government policies favoring sago management in the Regency of Meranti Islands is also very important. Appropriate government policies have a major impact on fundamental changes in the socio-cultural, economic, technological and ecological dimensions of sago sustainability management in the Regency of Meranti Islands.

Community-oriented development provides an opportunity for the community to participate actively in the development process to enjoy the development result. Development works well if there is good coordination between the government and the whole community. The process of community empowerment is a cycle or process that involves the role of the community to cooperate in formal and non-formal groups to study problems, plan, implement and evaluate jointly planned programs. Empowerment of farmer society includes Farmer Empowerment, Empowerment of Farmer Institution and Empowerment of Farmer Business. In addition, the empowerment of farming communities is able to contribute to the income of farmers of group members, including the more affordable fertilizer prices and capital assistance from farmers' organization. The leverage factor on the overall institutional dimension is shown in Figure 13.

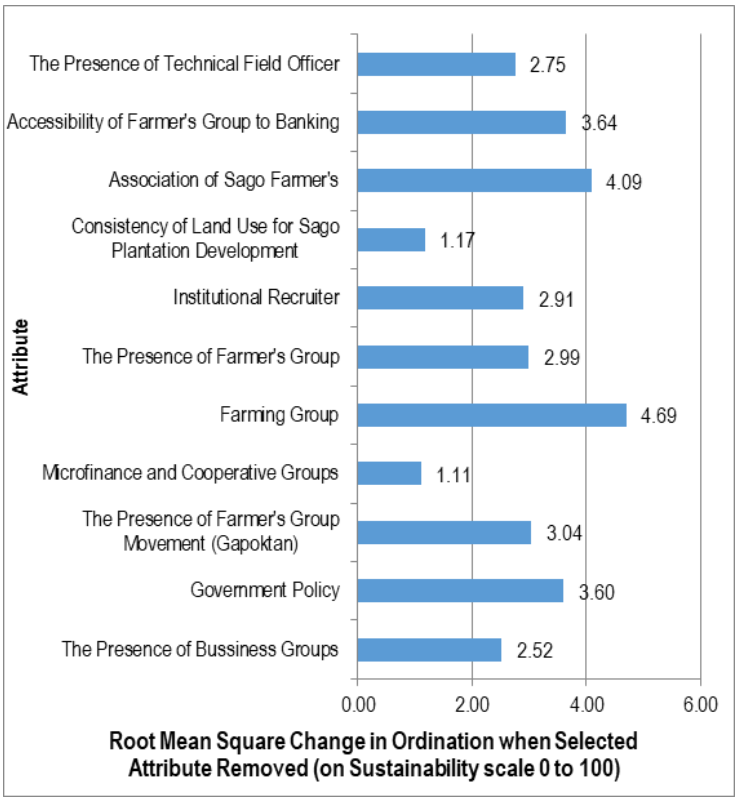

Figure 13. Leverage factor of institution dimension.

Multi-dimensional scaling and validation analysis. The result of analysis using MDS method resulted in sustainability index value of sago management functions. The sustainability status of social and cultural dimension, economics, ecology, technology and institutional dimension is categorized as less sustainable because it has a value <50 with an average value of 41.85. All dimensions are need to be considered because they fall into a less sustainable category with a sustainability value of <50. Thus, it is necessary to prioritize interventions across dimensions. Visualization of sustainability status between dimensions is shown in Figure 14.

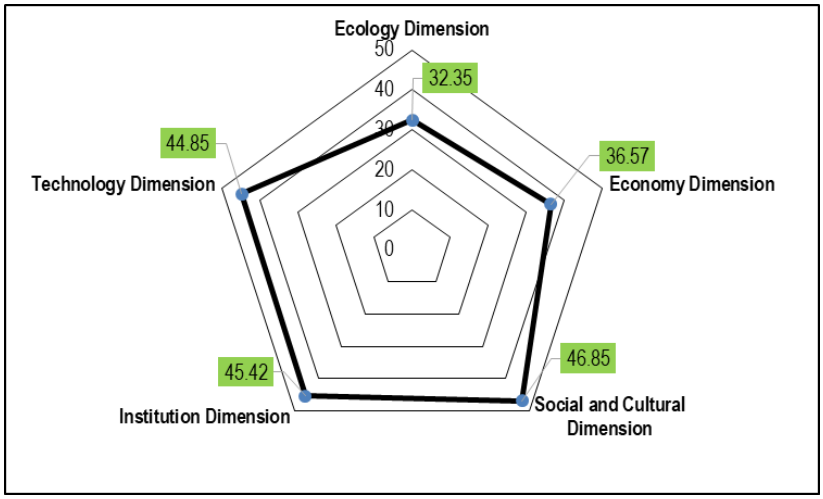

Figure 14. Visualization of sustainable index of sago management.

The MDS validation used Monte Ccarlo analysis, in which the difference in comparison of MDS analysis with montecarlo values is presented in Table 3.

Table 3

Monte Carlo analysis result for the sustainable index of sago processing

Indext status	*MDS*	*Monte Carlo*	*Gap*
Social and Cultural	46.85	47.13	0.28
Economic	36.57	37.27	0.70
Ecologic	32.35	33.99	1.64
Technologic	44.85	45.45	0.60
Institutional	45.42	45.39	0.03

In Table 3, it is seen that, the difference between the results of the analysis with MDS and Monte Carlo method is not more than 5% or very small. This proves the level of confidence in the total index (multidimension) and the trust of the index value of each dimension. Errors that may affect the analysis process by the MDS method have a difference of >5%.

Conclusions. The status of sago management and utilization sustainability in Regency of Meranti Islands was reviewed from 5 dimensions with 73 attributes classified on unsustainable sago management criteria. The sustainability index value of sago management and utilization ranged from 32.35 to 46.85. The ecological dimension is a priority aspect that needs to be addressed because it has the lowest MDS value of 32.35. Leverage factors that need to be improved on the ecological dimension are the area of sago land, water management, salinity, crop spacing and pollution levels. The dimension that has the highest MDS value and almost reaches the minimum limit of the sustainability index (50) is the socio-cultural dimension with an index value of 48.09. To achieve sustainability status in this dimension, the leverage factor must be improved. The main focus is on increase employment in sago management, reduce the percentage of the population which are below the poverty line and improve the formal education in the community. Sago is a potential commodity to be developed as staple food especially in Regency of Meranti Islands, but the current condition of all dimensions is still less sustainable. Therefore, it is necessary to manage sago in a planned, integrated and sustainable manner by taking into account the leverage factors of each dimension so that sago can be utilized for the independence of the Regency of Meranti Island, optimizing the utilization of sago in producing sago derivative products that have high competitiveness (quality), and contribute directly to the increased income of sago farmers and local revenue.

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