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Decision Support System for Determining Mini Sugar Mill Location in Madura

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Abstract

Madura has widely potential farming business of sugarcane and has enough raw material to build a mini sugar mill. Sugarcane is cultivated in Madura, particularly in four regencies, namely Bangkalan, Sampang, Pamekasan and Sumenep. To decide the location of mini sugar mill in one of the regencies requires decision support system (DSS). This study aimed to determine the priority of mini sugar mill location in Madura. This research used primary and secondary data. The primary data were collected using questionnaires. Then, the results of evaluation from the experts, on the items of questions, were analyzed with analytical hierarchy process (AHP). This was accomplished using Expert Choice 2000 software. Analysis of the selection of mini sugar mill location considered six criteria, namely the land suitability level, existing infrastructure, the potential of raw materials, the availability of labor, social capital and institutions. The selected criteria were further classified into sub-criteria to clarify the definitions of operational criteria and facilitate assessment for respondents. The results show that social capital had the greatest influence on decision making, followed by the land suitability level and the potential of raw materials. The finding in this research is that the mini sugar mill location is given priority in Bangkalan Regency, Madura. The conclusion of this research is that AHP analysis can be used as a method to take accurate decision in determining the location of sugarcane factory in certain area of sugarcane farming business development.

Keywords: AHP, Madura, mini sugar mill

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INTRODUCTION

Indonesia has 64 state-owned and private sugar mills, most of which have operated from the Dutch colonial era with an average grinding capacity of 3,000 TCD (tons of cans per day). The total national sugar production in 2016 amounted to 2.2 million tons, while the national sugar needs amounted to 5.7 million tons, comprising of 2.8 million tons to meet public demand and 2.9 million tons to meet industrial needs. Difference between the demands and the national production that reached 4.2 million tons was met by imports (BPS, 2015). Factors affecting sugar imports in Indonesia include domestic sugar stocks, sugar consumption, international sugar prices, and per capita income.

Most of the government-owned sugar mills have poor performance, especially from yield indicators (Bantacut, 2013), namely the crystal sugar production ratio produced against the weight of sugarcane milled. Factors that affect the yield include sugarcane raw material (SRM) quality and plant efficiency. Sugarcane quality is influenced by agro-climatic conditions, soil fertility, sugarcane varieties, cultivation techno-

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logy and management of cutting, loading and transport (CLT). Factory efficiency is influenced by the quality of SRM, engine conditions, engine age, production technology, quality of human resources and labor and management aspects.

In Brazil, most sugarcane farming has a high level of efficiency and competitiveness (Marin et al., 2013). Thus, the quality of SRMs for the sugar industry can be guaranteed. The quality of sugarcane is determined by variations of sugarcane varieties, agro-climatic conditions (Zhao and Li, 2015) and harvest timeliness (Xiao et al., 2017).

In Indonesia, in 2016, the general productivity of sugarcane decreased due to climate anomalies. Sugarcane productivity can be improved through molecular biology technological innovations (Da Silva et al., 2013), such as the development of sugarcane cultures that can adapt to climate change. Dianpratiwi et al. (2018) explain that several strategies that can be done to increase the productivity of sugarcane plants include increasing sugarcane farming area, adding organic fertilizer, ensuring the maximum water supply and cutting sugarcanes according to the level of maturity.

National sugar production can be boosted through increasing PG efficiency, improving SRM quality and sugarcane land expansion (extensification), improving the quality of human resources and management and adding new sugar mills. The development of sugar cane in dry land is one alternative to increase the national sugar production because the potential of the land is large enough and it fulfills the agroclimatic requirements for sugarcane cultivation. Madura is one area characterized with dry land which is very suitable for planting sugarcane with a fairly good intensity of solar radiation. Rainfall in Madura ranges from 1,000-2,000 mm with an average temperature of 26-27^{o}C and humidity between 75-85%, supported by a semi-flat topography that meets technical requirements for sugarcane cultivation (Andri et al., 2015).

The sugarcane area on Madura Island initially increased and reached in peak in 2013-2014, covering an area of 1,161 ha. However, the area subsequently decreased it was only about 601.2 ha in 2018, spreading in Bangkalan (416 ha), Sampang (77 ha), Pamekasan (107 ha) and Sumenep (1.2 ha) regencies. The development of sugarcane in Madura faces the challenges of socio-cultural factors and the decline in the existing sugarcane cultivation area; thus, building a sugar mill with a capacity of larger than 4,000 TCD is impossible. Meanwhile, if the sugar cane crop is sent continuously to the nearest area to Sidoarjo regency, there will be a decrease in yield and transportation costs are too high. The development of mini sugarcane-based sugar mills is the most realistic option to increase the contribution of Madura Island in supporting national sugar production.

The advantages of mini sugar mill include the lower investment costs, the relatively small SRM needs and the more guaranteed raw material freshness, flexible change in the availability of raw materials, as well as low requirements of labor and management (Bantacut, 2013). Moreover, mini sugar mill can be built close to the sources of raw materials, yields determination is more accurate and objective and the management control is easier.

The construction of a mini sugar mill in Madura requires a decision support system (DSS) based on multiple criteria that could affect the performance of mini sugar mill in the future. Multicriteria evaluation has been used for future development planning (Yu et al., 2009; Yu et al., 2011). Based on the experience of sugarcane development failure in Madura in 2012-2017, it is essential to compile a multicriteria system based on the consideration of experts from various disciplines. One method that can be implemented as a technique is the AHP (analytical hierarchy process). AHP method can simplify complex problems by creating hierarchies in the form of goals, criteria, sub-criteria and alternatives. Each can be compared in pairs to get the weight and priority to be chosen. With hierarchy, a complex problem can be broken down into a hierarchical form so that problems look more systematic and structured (Darmanto et al., 2014). AHP is one of the multi-criteria decision making (MCDM) approaches. The purpose of the MCDM is to choose a number of possible choices and goals. It is an effective tool for decision making (Gounaridis and Zaimes, 2012).

The criteria for determining the location of a sugar mill include demographics, costs, infrastructure and agro-climate. Fahrizal et al. (2014) used the Geographic Information System (GIS) method for spatial analysis of priority locations. They took advantage of GIS to identify optimal locations to convert biomass waste into biofuel. The integration of the MCDM approach

with the GIS produces a DSS that is spatially efficient to produce a land suitability map (Mendas and Delali, 2012).

Marin et al. (2013) argue that accurate land evaluation is essential in the decision-making process to support sustainable development. The criteria of land suitability is one of the determining indicators in DSS (Elaalem, 2012). The analysis results can be used to guide the preparation of agricultural land use plans (Al-Mashreki et al., 2011). Osly et al. (2015) used six criteria to determine the priority of sugarcane development areas in East Seram Regency, namely land suitability, infrastructure availability, water sources availability, land ownership status and labor availability. This study used AHP-based MCDM method with the help of the GIS. The study aimed to determine the priority of mini sugar mill location in Madura. This method was expected to be used by decision makers to develop a mini sugar mill in Madura.

MATERIALS AND METHOD

This research was conducted on the island of Madura, East Java, particularly in the regencies of Bangkalan, Sampang, Pamekasan and Sumenep. Locations were determined using the purposive sampling method, which considered that Madura Island is one of the sugarcane development areas in East Java with a projection of sugar mill construction.

This study used qualitative and quantitative approaches to find an interactive pattern of relationships. The stages in this study were classified as follows (Figure 1).

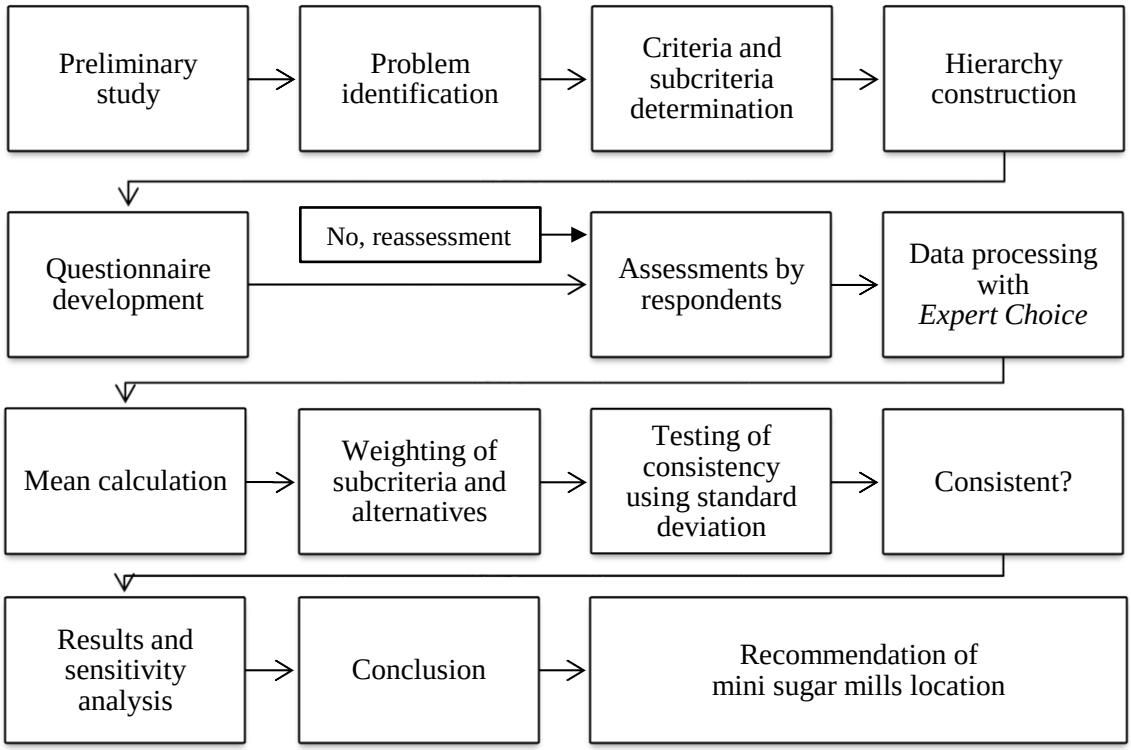

Figure 1. Research stages using the AHP method

[1] A preliminary study. A preliminary study was done to obtain a general depiction of Madura Island, agro-climate conditions and evaluation of sugarcane development programs. The preliminary study was carried out through the assessment of secondary data, surveys and interviews with sugarcane farmers, management of the State Sugar Cane Plantation Company (PTPN X), PTPN XI and Rajawali I Surabaya, LLC. A focus group discussion (FGD) was subsequently conducted with the Plantation Office of East Java Province, researchers, academics and plantation company experts. The FGD was completed to find out the planned construction of a mini sugar mill in Madura.

[2] Problem identification. The FGD determined several problems, alternative problem

solving and recommendations, including the problem of determining the location of mini sugar mill in Madura based on the criteria determined by expert judgment and the relevant research results.

[3] Criteria and sub-criteria determination.

[4] Hierarchy construction for decision making on the location of mini sugar mills.

[5] Preparation of questionnaires and interview guidelines. Data collection for AHP analysis used questionnaires and in-depth interviews with six respondents, consisting of researchers, government officers, academics, GIS experts, experts of Madura sociology and culture and plantation company management experts.

[6] Assessment of AHP objectives, criteria, sub-criteria and alternatives by respondents.

[7] Data processing with Expert Choice 2000 software.

[8] Geometric mean calculation.

[9] Weighting of subcriteria and alternative locations of mini sugar mills.

[10] Testing of consistency with standard deviation. Hierarchy consistency and expert judgment were declared to fulfill the requirements with a consistency ratio value or CR1 0.1. If CR $\geq$ 0.1, then the assessment must be repeated.

[11] Synthesis, results analysis and sensitivity analysis.

[12] Conclusion drawing based on AHP analysis results.

[13] Presentation of recommendation in the form of priority of Madura regencies to have a mini sugar mill. The research stages are presented in Figure 1.

The criteria and sub-criteria considered in determining the location of mini sugar mills are presented in Table 1. There were five criteria and twenty-one sub-criteria determined to select the location of mini sugar mills from four alternative regencies in Madura, namely Bangkalan, Sampang, Pamekasan and Sumenep.

The assessment of each level of the hierarchy was done through pairwise comparisons. Pairwise comparison assessments were carried out by respondents, by comparing the existing criteria, sub-criteria and alternatives for interest in decision making. Scale 1-9 was determined as a consideration in comparing pairs of each element in each level of the hierarchy to an element at the upper level (Saaty, 2008). The rating scales used are as follows (Marimin and Nurul, 2011).

1 = Element A is as important as Element B
3 = Element A is slightly more important than Element B
5 = Element A is more important than Element B
7 = Element A is far more important than Element B
9 = Element A is definitely more important than Element B
2, 4, 6, 8 = Middle rating (if the respondent doubts two adjacent values)
1/3 = Element B is slightly more important than Element A
1/5 = Element B is more important than Element A
1/7 = Element B is far more important than Element A
1/9 = Element B is definitely more important than Element A

Table 1. Criteria and sub-criteria for determining location alternatives

Criteria	Sub-criteria
Land suitability level	▪ S1 (Very appropriate) ▪ S2 (Slightly appropriate) ▪ S3 (Appropriate) ▪ N1 (Not appropriate)
Existing infrastructure	▪ Access to the provincial capital ▪ Distance to Tanjung Perak Harbour, Surabaya ▪ Road access for heavy equipment ▪ Drains (rivers) ▪ Water sources (wells)
Raw material potential	▪ Existing area of sugarcane ▪ Production potential ▪ Yield potential
Social capital	▪ Trust among farmers ▪ Farmers' trust of the government ▪ Solidarity and cooperation values ▪ Networking
Institution	▪ Partnership ▪ Providers of production facilities ▪ Capital institutions ▪ Cooperation ▪ Government policies

Lukoko and Mundia (2016) developed AHP analysis with GIS-based multicriteria analysis in order to decide the suitability of the sugar factory location in Trans Maya District. The GIS-based analysis consists of data collection, database development, data processing, analysis integration, display of analysis result and reporting. The result of GIS-based analysis becomes one of the criteria in AHP analysis. The nine criteria that determine the location of the sugar factory are decided based on the literature review, GIS-based analysis and expert opinion. AHP is used to obtain the relative importance (weight) for each specific criterion.

RESULTS AND DISCUSSION

Hierarchy Structure

The hierarchy consisted of goals, criteria, sub-criteria and alternatives. Figure 2 displays the decision to choose the location of a mini sugar mill in Madura.

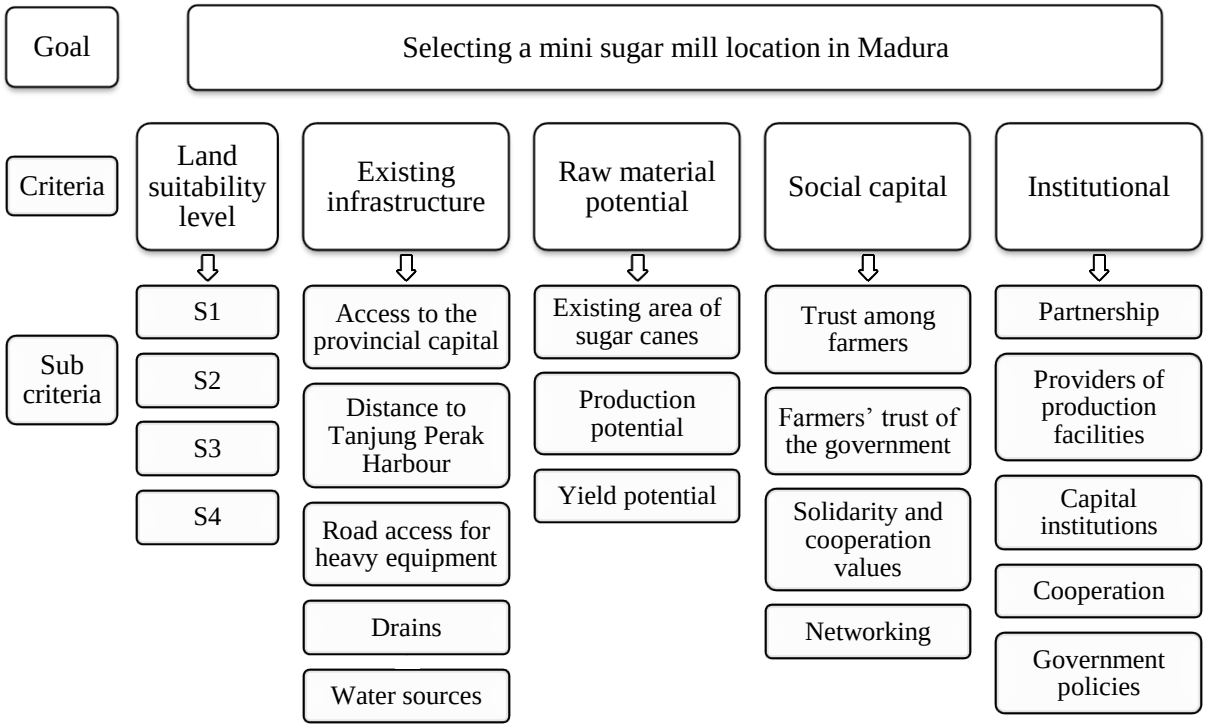

Figure 2. Hierarchy of determining mini sugar mill alternative locations

Pairwise comparison analysis

Pairwise comparison analysis was done by comparing criteria, sub-criteria and alternative locations of mini sugar mill for decision making. In pairwise comparison analysis, there was a comparison matrix between criteria, five comparison matrices between sub-criteria and five comparison matrices for alternative mini sugar mills locations based on sub-criteria. The results of the paired matrix comparison were in the form of priority weight.

Criteria evaluation results

The criteria for determining the location of a mini sugar mill in Madura consisted of the land suitability level, existing infrastructure, potential raw materials, labor availability, social capital and institutions. From the combination of the six respondents in pairs regarding the determining criteria for the location of the mini sugar mill in Madura, it appeared that the social capital was considered to be the most important criterion, followed by the land suitability level and then the raw material potential (Figure 3).

The social capital can be built through a) strengthening the trust among farmers, b). improvement of farmers' networking with the management of mini sugar mill, production facilities, capital institutions, marketing institutions, research institutions, universities and government, c) improving relations between farmers and the government and d) strengthening

the values of solidarity and cooperation among members of farmer groups and management of sugarcane farmer organizations.

The social capital criteria are also used by other researchers to formulate strategies to strengthen social capital in farmer groups. Wibisono and Darwanto (2016) use the analytic network process (ANP) method to analyze the social capital in developing agriculture. The strategy to fortify social capital can be done in the form of developing marketing institutions through the use of digital information networks. The development of agriculture will succeed if the role of social capital, such as mutual trust, participation and cooperation, can be optimized (Cahyono and Adhiatma, 2012).

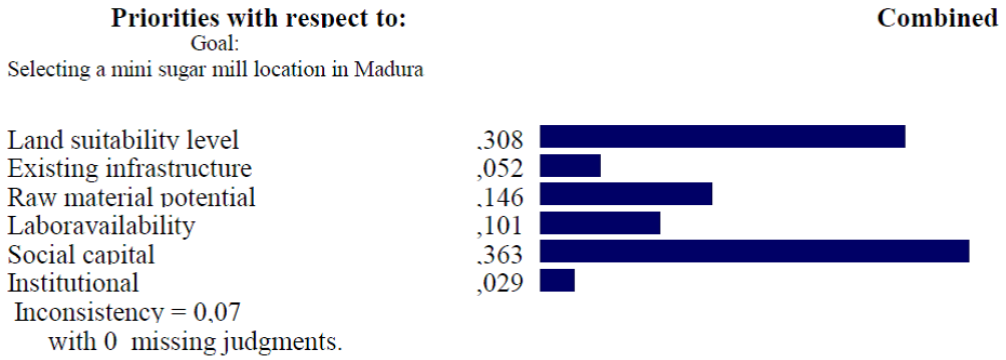

Figure 3. Criteria priority

Sub-criteria evaluation results

From the six pairs of respondents on the sub-criteria, it was found that the five most dominant sub-criteria in the selection of mini sugar mills in Madura were skilled labor, the area of existing sugarcane plants, S1 land suitability, trust among farmers and government policies.

The availability of skilled labor was selected as a sub-criterion with the greatest weight value, which was 0.733 (Figure 4). The skilled labor is more demanded for the development of sugarcane in Madura, both for farming activities (on-farm) and processing in mini sugar mill (off-farm). Workers with skills and expertise will have higher productivity. Improvement of workforce skills can be established through workshops, sugarcane field schools, counseling, technical training and management training. Besides its new production machine that suits the milling capacity of the mini sugar mill, the efficiency achieved by the mini sugar factory in India is also caused by the readiness of the labor to operate the machine properly, which meets the standard operating procedure made by the company that produces tools for mini sugar mill (Liboni et al., 2015).

One of the biggest components in the cost structure of sugarcane farming in Madura is labor costs, which is an average of IDR 12,481,463 per ha or 66.36% of the total cost of sugarcane farming. Even though the number of farm workers is quite large, the productivity of local labor is low. During the 2012-2017 period, sugarcane cultivation activities, especially for CLT activities, often brought in workers from outside Madura so that the CLT costs increased. The average CLT cost incurred by farmers was IDR 10,125,366 per ha. The CLT cost component was the largest component for sugarcane farming costs (53.83%) of the total costs that reached 72.20% of the variable costs. The farther the location of the farm from the sugar mill, the greater the CLT cost for farmers.

The total area of sugarcane in Madura Island in 2018 was approximately 601.2 ha, spreading in four regencies. Milling capacity that is in line with the potential of SRM in Madura is currently 500 TCD. A mini sugar mill with a capacity of 500 TCD with a normal milling day of at least 150 days requires SRM of 75,000 tons per milling season. With sugarcane production on dry land reaches an average of 60 tons per ha, the minimum area of sugarcane needed is 1,250 ha. Increasing the supply of SRM can be done by opening a new farm, buying from farmers (Bantacut, 2013) and increasing crop productivity and yields.

The quality of SRMs will greatly determine the quality of the sugar produced. Sugarcane plants that are harvested at the right time will improve the production of sugar (Amolo et al., 2014). Milled raw materials must be mature, clean and fresh (P3GI, 2010; Rukmana, 2015). The criteria

for mature cane and proper cutting are that they have a ± 25 Maturity Factor (MF), ± 100 Coefficient of Durability (CD), ± 100 Coefficient of Increase (CI), Brix First Roomie Sap (FRS) ≥20%, NPP> 16%, Purity Degree (PD)> 80% and reduced sugar content <0.5%. Sugar cane is said to be clean if it is free from dirt (<5%). Dirt in question is *daduk*, shoots, *sogolan*, roots, soil and other plants. Sugarcane is declared fresh if it has a pH of 5.4-5.8 and the storage duration of sugarcane, from cutting down into putting on the ground, is not more than 24 hours.

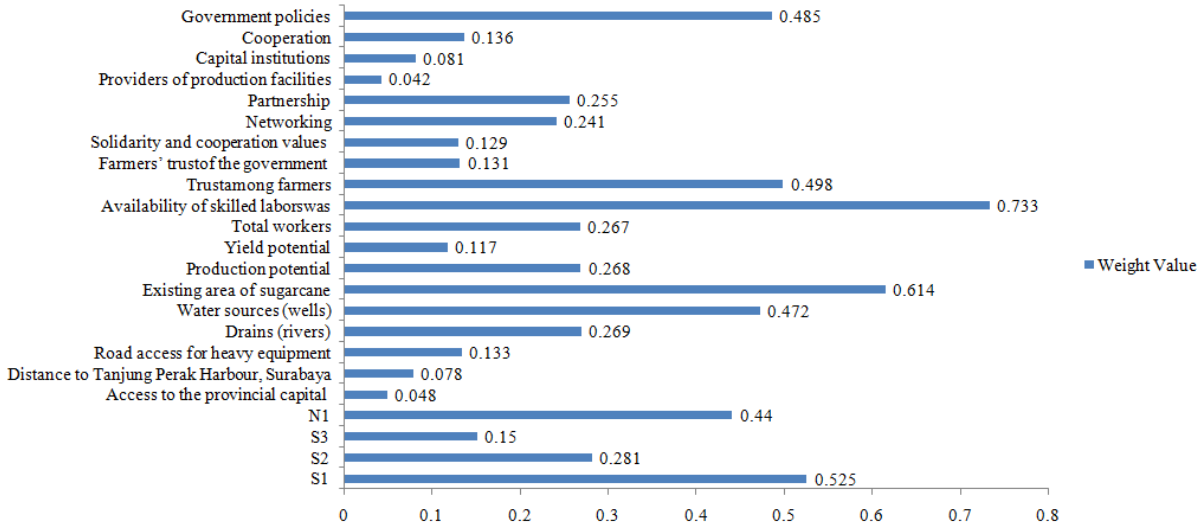

Figure 4. Sub-criteria priority

Based on the agro-climate, the land suitability level can be divided into S1, S2, S3 and N1 (Table 2). The S1 priority weight value was 0.525 and it was in third place among 21 sub-criteria. This is caused by the fact that the sugarcanes land suitability level affects productivity and yield. Land with land suitability level of S1 had higher productivity and yield potential than lands with the land suitability level of S2, S3 and N1.

Table 2. Sugarcanes land suitability level

Regency	Sugarcanes land suitability level (ha)			
	S1	S2	S3	N1
Bangkalan	23,599.1	54,529.9	40,430.9	12,216.0
Pamekasan	12,853.1	15,959.8	38,060.9	14,846.2
Sampang	13,501.1	41,937.8	54,861.2	13,341.5
Sumenep	7,629.3	36,583.3	53,777.7	17,420.5
Total	57,582.6	149,010.8	187,130.7	57,824.2
%	12.8	33.0	41.4	12.8

Source: Developed from analysis results, 2018.

Based on respondents' assessment, the sub-criteria of trust among farmers had the highest priority weight (0.498) compared to the other sub-criteria of social capital and it was the fourth highest priority weight of all sub-criteria.

Based on the studies, land regrouping is one alternative to improve the efficiency of sugarcane cultivation. With the regrouping model, it is possible to apply the mechanization of sugarcane cultivation so that technical efficiency is achieved (Andri et al., 2015). The main obstacles in implementing mechanization in Madura are the small area of farmers' land (0.25-0.5 ha) and farmers' insistance on maintaining land boundaries such as rice fields, *galengan* or embankment, trees and other boundaries based on local wisdom. Farmers are not willing to

accommodate mechanization by eliminating their land boundaries.

Even though there are digital technologies to measure land area, the farmers think that using physical boundaries are more credible. Trust among farmers is one of the important keys for land regrouping. The unity and trust of farmers towards the government also have a positive effect on the implementation of land regrouping model and the mechanization of sugarcane cultivation in Madura. Achieving technical efficiency provides greater opportunities for obtaining allocative and economic efficiency. If sugarcane farming is able to deliver higher efficiency, it will better guarantee the adequacy of sugar cane raw materials for mini sugar mills. If the social culture of the Madurese community can be conditioned to achieve these three efficiency indicators, the potential for productivity and sugarcane yield will be improved.

In their study, Ferhat et al. (2018) found that land regrouping in the Gempolkrep sugar mill area did not significantly affect the increase in sugarcane production. However, the use of inputs was relatively more efficient than non-regrouping sugarcane farming. With the land regrouping, the mechanism in sugarcane cultivation is easy to implement; thus, making it more efficient (Bautista et al., 2017). Moreover, the cost of sugarcane farming can be minimized (Padilla-fernandez and Nuthall, 2009). Most of the sugarcane farmers in the Philippines consider that the implementation of mechanization is more profitable than the manual system because it uses less human labor and the machine productivity is higher (Bautista et al., 2017). However, the inhibiting factor of mechanization in the Philippines is the high price of agricultural machinery. Therefore, support from the banks and the government in the form of soft loans are essential for the development of mechanization.

Social capital works when there has been interaction with other people guided by social structures (Yustika, 2008). An interaction can occur at individual or institutional level. Interactions occur at individual level when close relationships between individuals are formed with each other based on mutual trust which then develop an emotional bond. Interactions at institutional level can be born when the visions and goals of an organization have something in common with those of other organizations.

An institution is an order and pattern of relations between farmers both individually and in groups with other parties to achieve common goals in the development of sugarcane in Madura such as partnerships, providers of production facilities, capital institutions and cooperations. Moreover, institutions are also related to government policies to support the development of mini sugar mills. Some researchers, such as Said (2012), Sis et al. (2013) and Allahdadi (2011), agree that farmer institutions such as farmer groups and cooperation are effective to solve problems faced by farmer groups as well as contribute to economic growth. Partnerships between farmers and companies are one of the institutional forms that can be developed to increase farmers' income (Mercy et al., 2013). However, partnership can run well when it involves all stakeholders (Waswa et al., 2012).

According to Kusnandar et al. (2013), an institutional model for the development of agribusiness in a rural area should include upstream agribusiness, farming, downstream agribusiness and agro-industry. However, to enhance the contribution of agribusiness institutional, government interference is needed (Nuraini et al., 2016)

Based on the respondent's assessment, the government policy was ranked fifth, with a priority weight of 0.485 (48.5%). Compared to other sub-criteria in the institutional criteria, government policy had the highest weight value, while the partnership was ranked second with a priority weight of 0.25 (25.5%).

There are regional regulations in East Java Province governing sugarcane cultivation, increasing crystal and yield, namely Regional Government Regulation Number 17 Year 2012. Constructing a mini sugar mill in Madura requires government' support in the form of policies, including national, provincial, and regional governments' regulations. Governor Regulation, Regent Regulations or other legal products such as the Decree governing the development of sugar cane and mini sugar mills in Madura are essential.

The partnership between sugarcane farmers and sugar companies is vital in the development of sugarcane and mini sugar mills in Madura. This is related to the certainty of raw material production for the sugar company and the guarantee of production and prices for the farmers. At the State Sugar Company and the private sugar company, a partnership is a key to

the existence of the company. Sugar mills that do not establish partnerships with farmers will have a lack of SRM. The partnership also improves the potential of SRM that meets the quality standards required by sugar companies. The partnership model can be in the forms of production contracts, plasma nuclei or general trading patterns.

Priority of mini sugar mill location

With consideration of all criteria and sub-criteria to determine the location of mini sugar mills in Madura, respondents agreed to choose Bangkalan as the first priority, followed by Sampang Regency and then Pamekasan Regency.

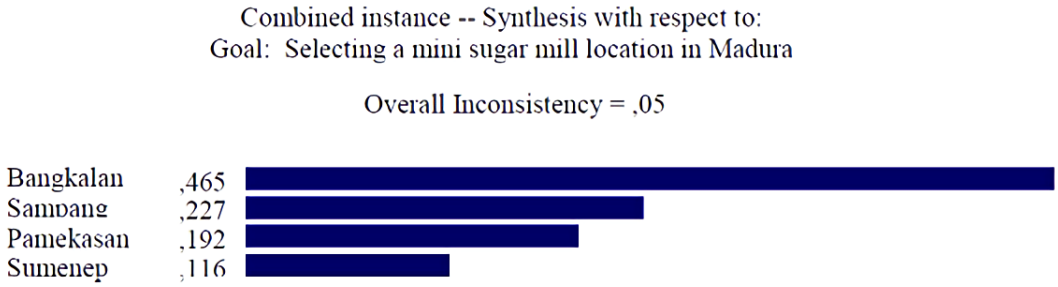

Figure 5. Priority of mini sugar mill location based on a combination of all criteria

The results show that based on the land suitability level, existing infrastructure, potential raw materials, availability of labor, social capital and institutional, respondents agreed to choose Bangkalan district as the first priority for location mini sugar mills with a priority weight of 0.465 (Figure 5).

Sampang Regency was the second priority for the location of mini sugar mills with the priority weight of 0.277 (Figure 6). Geographically, Sampang Regency is situated between Bangkalan and Pamekasan. The pairwise comparison analysis results show that based on the land suitability level, existing infrastructure and raw material potential criteria, Sampang was ranked second after Bangkalan, with a priority weight of 0.275, 0.268 and 0.208, respectively. Furthermore, Sampang had nearly similar priority weight in the raw material potential criterion to Pamekasan, which obtained 0.205.

Pamekasan Regency was the third priority for the mini sugar mill location, with a priority weight of 0.192. For the criteria of availability of labor, social capital and institutions, Pamekasan had a higher priority weight than Sampang and Sumenep, but lower than Bangkalan.

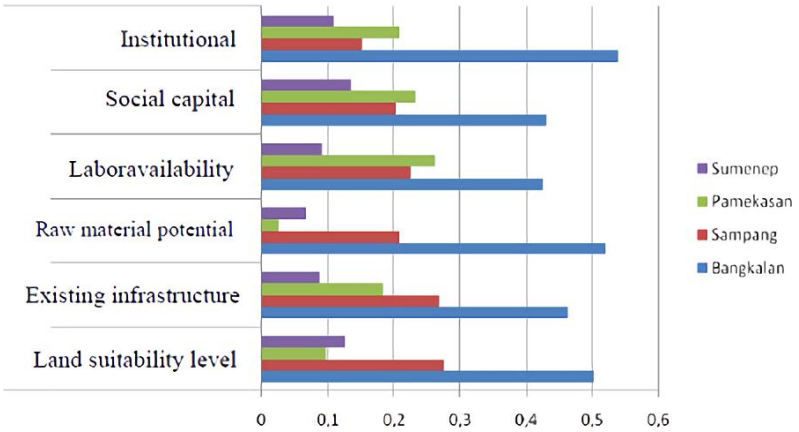

Figure 6. Alternatives to mini sugar mill location based on each criterion

Developing Madura sugarcane industry and building mini sugar mills in Madura are the right things to do, regarding the availability of its land area. As has been explained by (Sulaiman et al., 2019), some sugar factories in Indonesia are no longer efficient. Therefore, they need to be

revitalized or we need to build new factories. The construction of new factories should be adjusted to the raw material and the readiness of the labor in that region.

Consistency ratio

The consistency ratio analysis results for all paired comparisons between criteria, sub-criteria and alternatives obtained inconsistency values <1 (<10%). This means that respondents' assessment was at the inconsistency level that is allowed in AHP analysis.

Sensitivity analysis

Sensitivity analysis results were used to observe the components or elements of the hierarchical structure that were the most sensitive to changes in weight, resulting in an alternative change in the location of the mini sugar mill in Madura. In the operational level, sensitivity analysis is used to observe to how extent the criteria can influence the determination of priority alternatives.

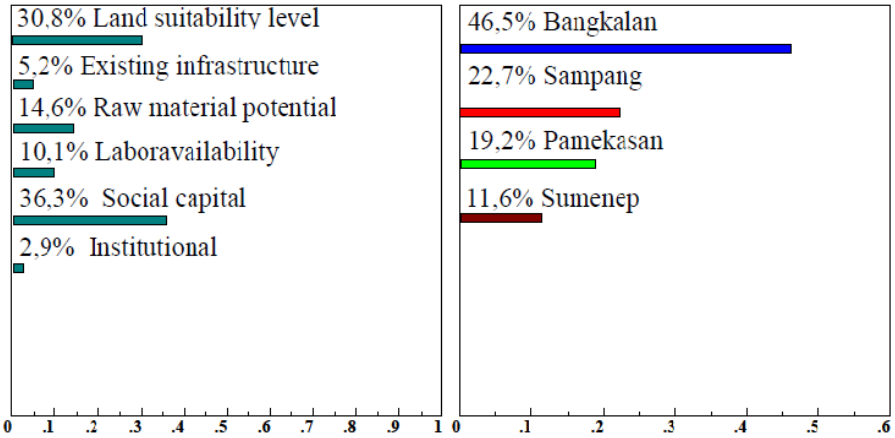

Figure 7. Dynamic sensitivity for nodes below in selecting mini sugar mill location in Madura

As presented in Figure 7, the criterion that was most sensitive to weight change that affected alternative priorities was the social capital with a weight of 36.3% while the lowest value was obtained by the institutional form with a weight of 2.9%. This means that changes in the weighting of the social capital criterion affect four alternatives for the selection of the appropriate mini sugar mill locations.

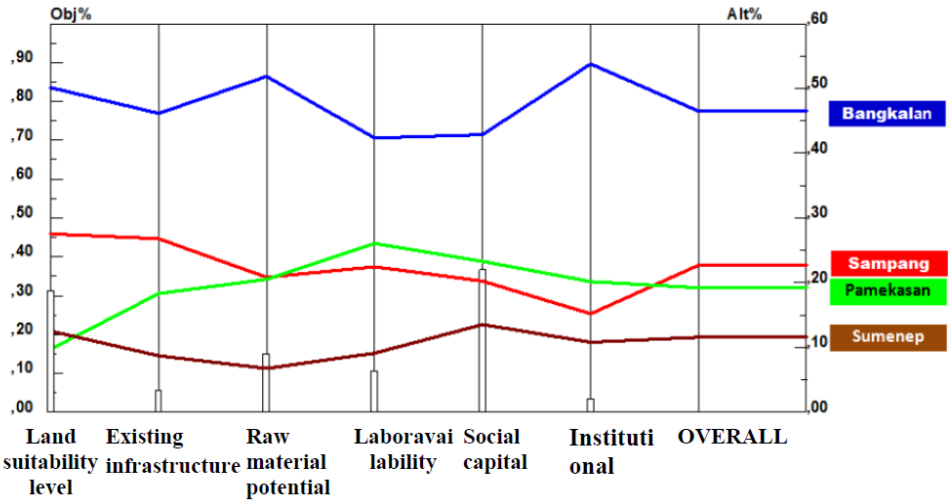

Figure 8. The sensitivity of mini sugar mill location selection

The simulation was done by increasing and decreasing the weight of each criterion by 10% and the effect on the previously selected recommendations was observed. For example, the

10% decline in the value of the social capital criterion in Sampang district would change its ranking of alternative locations for mini sugar mill (Figure 8). Originally, Pamekasan Regency was ranked third, it then moved to the second alternative location.

CONCLUSIONS

The results show that (1) the highest weight was obtained by social capital criterion, then followed by the land suitability level and the raw materials potential, (2) the results of the sub-criteria comparison analysis reveal that the five most dominant sub-criteria for consideration to select the location of mini sugar mills in Madura were skilled labor, extensive existing sugarcane plants, S1 land suitability level, trust among farmers and government policies and (3) the AHP analysis results indicate that the best priority for the location to establish mini sugar mills is Bangkalan district.

Recommendation

- Based on the criteria and sub-criteria that are used as considerations to determine the location of the mini sugar mill, the recommended place to be the location of the mini sugar mills is Bangkalan district.
- Skilled labor force, extensive existing sugarcane plants, S1 land suitability level, trust among farmers and government policies are the five main criteria that should be considered by the policy makers when deciding the location for mini sugar mills in Madura.
- Future research could use more sub-criteria of social capital to design the AHP structure as the results show that the social capital had the highest weight. In addition, the sub-criteria of social capital also received considerable priority weight.
- The study of social capital as one of the criteria for decision making in determining the location of a sugar mill can be applied to decision-making criteria on other research. Moreover, a more in-depth study of the role of social capital in developing sugar cane commodities and mini sugar companies with a qualitative approach could be explored.

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