A Multidimensional Approach in Assessing Geographical Indication Product Sustainability: Salak Pondoh Sleman

Rizky Brisha Nuary[1*], Mochammad Maksum[2], Anggoro Cahyo Sukartiko[2]

[1]Department of Agricultural Product Technology, Vocational School, Universitas Sebelas Maret (UNS), Jl. Ir. Sutami No. 36, Kentingan, Kec. Jebres, Kota Surakarta 57126, Indonesia
[2]Department of Agro-Industrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Jl. Flora No. 1, Bulaksumur, Yogyakarta 55281, Indonesia
[*]Corresponding author: Rizky Brisha Nuary, Email: rbnuary@staff.uns.ac.id

Submitted: July 1, 2020; Revised: October 7, 2020; Accepted: February 8, 2021

ABSTRACT

Salak Pondoh Sleman (SPS) is an exotic fruit which has geographical indication certification, a sign indicating the unique characteristics inherent in a product due to the influence of its geographical origin. Its unique characteristics can only be found in certain areas. Thus, it is necessary to consider the concept of sustainable agricultural development of the product, involving several dimensions such as environmental, organizational, and technological. The study aimed to assess the sustainability of SPS as a product with geographical indication certification and identify the most influential sustainability attributes in the selected dimensions. A rapid appraisal method of the multidimensional scaling technique was performed to achieve the objective of this study, further mentioned as RAPSalacca. The result showed that the sustainability level of SPS plantation system was classified as 'quite sustainable,' with a sustainability index of 59.83. Furthermore, the sustainability analysis of the selected dimensions denoted the important attributes to the sustainability in each dimension, which is further explained in this paper.

Keywords: Geographical indication; RAPsalacca; salak pondoh sleman; sustainable agriculture

INTRODUCTION

As an archipelagic state, Indonesia has various potential natural resources that can be developed as an effort to improve the local economy. The wealth and uniqueness of natural resources in Indonesia are able to produce different products as linked to their geographical origins. Thus, the products can provide special characteristics that are identical to certain regions, further known as geographical indications (Neilson, Wright, & Aklimawati, 2018) it is anticipated, producers can capture the place-related value embodied within a product. As such, they are often promoted as a development initiative for lagging rural communities to improve livelihoods and alleviate poverty. This article applies the concepts of value capture and strategic coupling from the Global Production Networks (GPN). The Indonesian government proves their concern in implementing the geographical indication policy with the legalization of Law No. 20 of 2016 concerning Marks and Geographical Indications. The Directorate General of Intellectual Property (DGIP) of Indonesia showed that up to 2018, about 65 commodities have been registered in geographical indications (DGIP, 2018). The registered commodities have been proven to have unique characteristics distinguishing them from similar products originated from other territories related to their geographical origin, or the culture of their local community, or both.

DGIP (2018) also showed that about 86.57% of the registered GI products in Indonesia were categorized as

DOI: http://doi.org/10.22146/agritech.57506
ISSN 0216-0455 (Print), ISSN 2527-3825 (Online)

agricultural products. Agricultural products usually have qualities that originate from their place of origin and are influenced by specific geographical environmental factors, such as climate and soil (Fernández-Ferrín *et al*., 2019; Joshi, Maharjan, & Piya, 2011). Due to their special characteristics, the products can only be found and cultivated in specific places, therefore, the concept of sustainable agriculture on geographical indication products is required. Sustainable agricultural management is necessary for balancing the agricultural product needs of present and future generations (Erbaugh, Bierbaum, Castilleja, da Fonseca, & Hansen, 2019; FAO, 2016)

Salak Pondoh Sleman (SPS), an agriculture commodity that has had geographical indication certification since 2013, is asserted to have a special characteristic that differentiates it from similar crops cultivated in other regions (KPIG-SPS, 2012). The quality of SPS is generally determined by its sweetness, yet the degree of sweetness varies due to different cultivation altitudes (Suhandy *et al*., 2010) low cost portable spectrometer (VISNIR USB4000. Recent comparative studies of the snake fruits' characteristics in Indonesia showed that SPS tends to have a lower tannin content and higher notation *b** value, thus generating a yellowish fruit (Puspitasari, 2016). In addition, a discrimination testing of mineral contents showed that the combination of iron (Fe) and manganese (Mn) elements has been able to distinguish SPS with snake fruits originating from other regions (Sukartiko, Puspitasari, & Nuary, 2017).

Nuary *et al*., (2019b) maintaining its sustainability is importantly required. This study aims to determine the sustainability status of Salak Pondoh Sleman farming system based on its sustainability index, specifically in a socio-economic perspective. To achieve the goal, the socio-economic factor that influences the sustainability status of Salak Pondoh Sleman farming system was determined. Economic sustainability was assessed based on income, selling price, and farming costs, while social sustainability was reviewed based on the participation of farmers in their group. A structured questionnaire was developed and distributed through a survey in three subdistricts area within Sleman subdistrict, namely Tempel, Turi, and Pakem in 2019. A multi-dimensional scaling for Rapid Assessment Techniques for Salacca (RAPSalacca) reviewed the socio-economics perspectives on the sustainability farming system of SPS and presented the influential factors. In contrast to the past research paper, this study dealt with attributes that affected SPS characteristics. According to KPIG-SPS (2012), the inherent characteristics of SPS are caused by the influence of the plantation environment and cultivation techniques that have been done over generations. Since cultivation techniques can affect the quality of agricultural products (Gruda, Bisbis, & Tanny, 2019; Mahajan *et al*., 2017), an approach of SPS plantation system was used to assess the sustainability status of the geographical indication certification on SPS, specifically in terms of the environment, organization, and technology dimensions. Therefore, the objectives of this study were to evaluate the sustainability level of SPS as a product with geographical indication certification and identify the most important sustainability attributes in the selected dimensions.

MATERIALS AND METHODS

Research Framework

This study was performed in two stages of in-depth interviews (Figure 1). The first stage aimed to create the sustainability attributes of the selected dimensions. The sustainability attributes of the geographical indication product, specifically in the SPS plantation, have never been obtained. Thus, a variety of actions were carried out, including a literature review of publications, regulations, and related documents containing sustainable horticultural practices. Six respondents, as the experts, were the local regulator and stakeholders of SPS, i.e., Department of Agriculture, Food, and Fisheries of Sleman Regency, the extension agents from the Agricultural, Food, and Fisheries Extension Unit, and also *Masyarakat Perlindungan Indikasi Geografis.* Brownstein, Louis, O'Hagan, & Pendergast (2019) stated that the selected experts must have deep knowledge, skills, and other supporting documents on the selected topic. The respondents in this study were selected based on the mentioned criteria and represented the involved stakeholders. Furthermore, through expert judgment, the literature study was discussed and selected as measured attributes to assess the sustainability of the SPS plantation system.

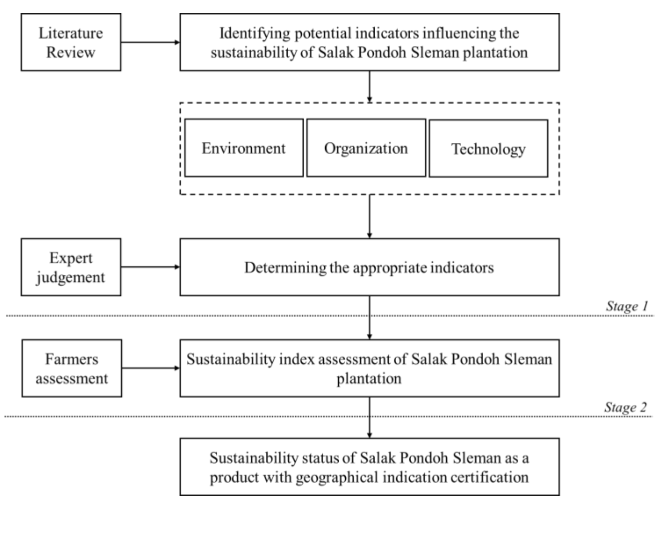


Figure 1. Research framework

The second stage of this study was conducted to assess the sustainability index of the SPS plantation system. One hundred respondents, selected by a proportional random sampling technique, were farmers of SPS in Sleman, specifically Tempel, Turi, and Pakem subdistricts (Figure 2). A total of 27 attributes corresponding to three dimensions were scaled based on in-depth interviews to assess the sustainability of the SPS plantation. The score of each attribute had been predetermined. The higher the given score, the better the condition of the corresponding attribute and vice versa. The overall results of the attributes in the selected dimensions are presented in Appendix A. Then, the attributes were grouped based on the selected dimensions and sorted based on the leverage value. The attribute with the highest leverage value in each dimension was selected for consideration of future improvements.

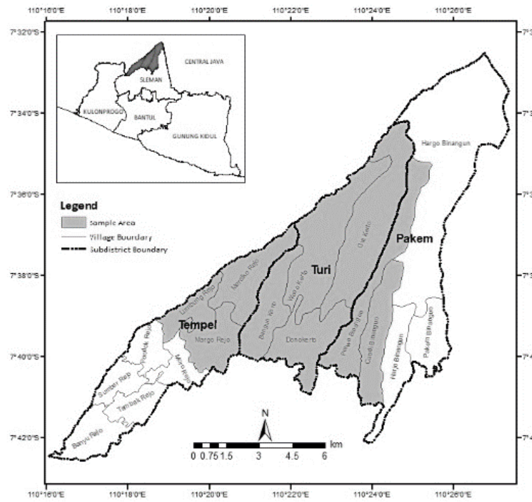


Figure 2. Map of the observed area. The specific location of the surveyed SPS farmers at the village level is shown in grey

RAPSalacca

RAPSalacca, a modified RAPFish technique (Kavanagh & Pitcher, 2004; Pitcher *et al*., 2013), was used to assess the sustainability of the SPS plantation system (Nuary *et al*., 2019b) maintaining its sustainability is importantly required. This study aims to determine the sustainability status of Salak Pondoh Sleman farming system based on its sustainability index, specifically in a socio-economic perspective. To achieve the goal, the socio-economic factor that influences the sustainability status of Salak Pondoh Sleman farming system was determined. Economic sustainability was assessed based on income, selling price, and farming costs, while social sustainability was reviewed based on the participation of farmers in their group. A structured questionnaire was developed and distributed through a survey in three subdistricts area within Sleman subdistrict, namely Tempel, Turi, and Pakem in 2019. A multi-dimensional scaling for Rapid Assessment Techniques for Salacca (RAPSalacca). Statistically, Goodness-of-fit was evaluated using stress values, while the uncertainty in each attribute was expressed through Monte Carlo runs. In this study, RAPSalacca was used to evaluate the sustainability of the SPS plantation system through different attributes by considering environmental, organizational, and technological dimensions. RAPSalacca analysis was executed with Microsoft Excel in Office 365 version using a provided algorithm in its add-in features (Kavanagh & Pitcher, 2004).

RESULT AND DISCUSSION

Sustainability Status of SPS Plantation System by Selected Dimensions

The determination of the sustainability status of the SPS plantation system was based on the obtained sustainability index score, subsequently, classified into

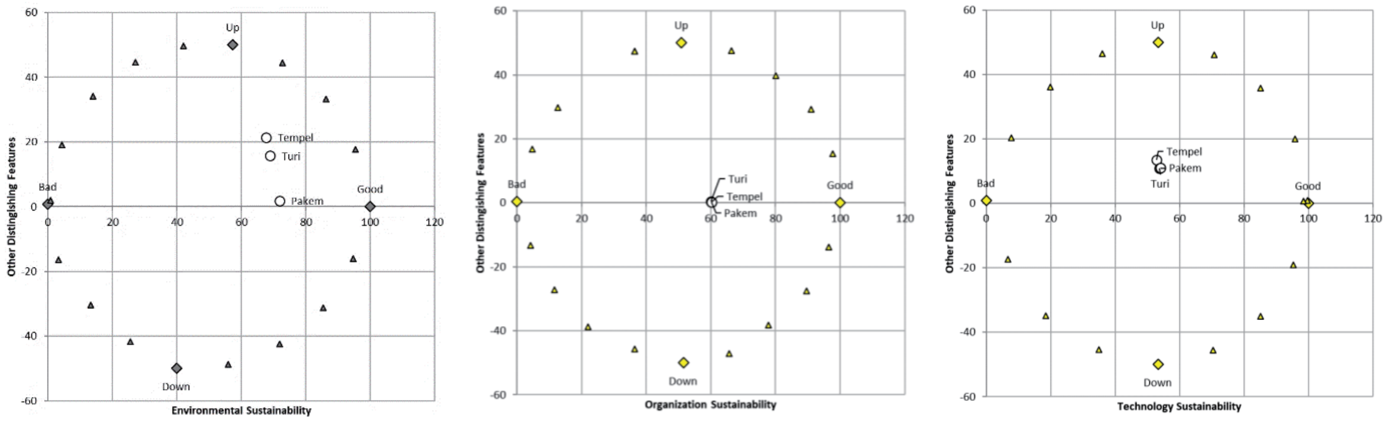
Table 1. Sustainability index of each dimension according to RAPSalacca ordination and statistical values of MDS analysis

	Dimensions			Sustainability index*)
	Environment	Organization	Technology	
MDS value	66.48	59.45	53.55	59.83
Stress (<0.25)	0.14	0.14	0.15	0.14
R^2 (>0.80)	0.95	0.95	0.95	0.95
Monte carlo analysis				
Average	65.91	58.82	53.24	59.32
Differences	0.57	0.63	0.31	0.05

Notes: *) Calculated by selected influential attributes from each dimension

Table 2. Sustainability index of selected subdistricts

Subdistrict	Dimensions			Mean	Rank
	Environment	Organization	Technology		
Pakem	71.98	60.28	54.05	62.10	1
Turi	68.87	60.02	53.7	60.86	2
Tempel	67.66	60.18	52.82	60.22	3



(a) (b) (c)

Figure 3. Two-dimensional RAPSalacca ordinations of the SPS plantation by subdistrict. The sustainability index is shown in white bullets, the horizontal axis denotes sustainability scores between 0% and 100% or the ‘bad’ and ‘good’, while the vertical axis denotes differences among farmers not related to sustainability. (a) environmental dimension; (b) organizational dimension; (c) technological dimension

four categories referring to Dzikrillah *et al.*, (2017) and Papilo *et al.*, (2018). The results showed that the sustainability index of the SPS plantation system was identified (Table 1) and classified as ‘quite sustainable’ (59.83). Moreover, the two-dimensional RAPSalacca ordination of each dimension, a coordination point that represents the sustainability index, showed an adjacent coordinate (Figure 3) for both the vertical dan horizontal axes. This result indicated that there was less variation in the scores among farmers in the selected subdistricts, as the Kruskal’s stress, RSQ values, and the difference of averaged Monte Carlo and MDS showed good results for all the dimensions (Kavanagh & Pitcher, 2004). The technological dimension showed the greatest variation and the lowest scores for sustainability, whereas the organizational and technological dimensions, in contrast, showed less variation.

Generally, the environment was the dimension with the highest sustainability index value (66.48), followed by the organization (59.45), and technology (53.55). The result revealed that all the selected dimensions fell into ‘quite sustainable,’ indicating that, the aspects of the environmental quality and its surrounding agricultural resources, the organization system, and the technology applied in the SPS plantation system were quite feasible and able to support sustainable agricultural activities. A further investigation showed the overall sustainability index of the selected subdistricts (Table 2), in which Pakem ranked the first, followed by Turi and Tempel, respectively. The table also indicates that all the observed areas were ‘quite sustainable’ (60.22 to 62.10).

Environmentally, the SPS plantation system was categorized as relatively ‘quite sustainable,’ though Pakem was almost categorized as strongly sustainable.’ Most SPS farmers in Sleman had adopted organic farming practices, indeed, they had organic certification. The organic farming practice was proven to be able to support the sustainability of the fruit farming system (Borsato *et al.*, 2020; Conti *et al.*, 2014; González, Marquès, Nadal, & Domingo, 2019), evidenced by reduced environmental pollutants; better water, carbon, and soil features; no economic losses. Furthermore, this study involved climate change factors as SPS is vulnerable to climate change (Nuary, Sukartiko, & Maksum, 2019a), in which

Table 3. The most influential attributes in selected dimensions for SPS plantation system sustainability

Dimensions	Attributes	Leverage value
Environment	Irrigation system availability	6.06
Environment	Land conversion/land-use change	4.36
Environment	Chemical fertilizer usage per hectare	4.24
Environment	Regional spatial plan suitability	3.99
Environment	Land slope class	3.92
Environment	Prediction of land suitability under the risk of climate change	3.56
Organization	Conflicts between the organizations	4.28
Organization	Number of agricultural extension agents	2.60
Organization	Marketing organization	2.50
Organization	Number of professional companions	2.43
Organization	The intensity of group meetings	2.30
Organization	Female farmer groups	2.00
Technology	Product quality classification	3.39
Technology	Harvest technique	2.84
Technology	Post-harvest treatment	2.06

surprisingly, the environmental attribute obtained the lowest score. Following Irwansyah (2016), the evidence of climate change in Indonesia has been found, including changes in rainfall, air temperature, water shortages, crop failures, and frequent extreme weather.

In the organizational dimension, the overall sustainability index of the SPS plantation system was found to be greater than 50.00, making it under the 'quite sustainable' category. As agriculture sustainability develops dynamically, having organization-based management is necessary to develop an equitable economy and guarantee the social well-being of the community (Benos, Kalogeras, Verhees, Sergaki, & Pennings, 2016), which leads to its sustainability. The SPS farmers had a good organizational structure, reflected by the existence of farmer associations consisting of farmers from Tempel, Turi, and Pakem, named as 'Asosiasi Petani Salak Pondoh Sleman,' and the 'Asosiasi Mitra Turindo'. Under the mentioned associations, there is a 'gapoktan', a group consisting of all the farmer groups, and 'Komunitas Perlindungan Indikasi Geografis', a group consisting of the people in charge of its geographical indication management, specifically to meet the geographical indication's requirements. Generally, a farmer group consists of about 22 to 89 farmers scattered across Tempel, Turi, and Pakem.

The technological dimension obtained the lowest sustainability index, yet still categorized as 'quite sustainable' though the values were only slightly higher than the 'less sustainable' category. Most of the SPS farmers were smallholders; hence, agricultural innovations and technologies were limited mainly due to the weak financial investments (Adenle, Wedig, & Azadi, 2019). The applied technologies were common for all the farmers and there was no specific technology adopted. All the applied technology strictly referred to Buku Persyaratan Indikasi Geografis, a handbook for the implementation and quality standard specifications for geographical indications product. In relation to the technological dimension, the product quality classification was the attributes with the lowest score.

Factors Affecting the Sustainability Status of SPS Plantation System

The important factors influencing the sustainability status in this study were done by selecting the priority attributes with the highest leverage value in each dimension (Table 3). As mentioned by Kavanagh *et al.*, (2004), leverage value reflecting the sustainability attributes ranges between 2% to 6%, hence, 15 of 27 attributes were selected as the important sustainability attributes. The selected attributes can be used by policy-maker as a consideration to develop sustainable agricultural policies in the future.

Irrigation system availability (6.06) was the most important attribute within the environmental dimension, or even within all the selected dimensions, except the fact that the environmental dimension showed the highest sustainable index. Considering climate change, as the attribute with the lowest score in this dimension, a proper irrigation system is necessary for maintaining sufficient water supply. A further investigation showed that the main problem in the SPS cultivation was water abundance in the rainy season and water shortage in the dry season. A prolonged rainy season will cause fruits to be rotten more quickly due to a pollination issue, while a prolonged dry season will cause plants to be wilting, thus resulting in crop failures (Prasetyo, Mu'in, & Wirianata, 2017). Consequently, it is important to pay more attention to irrigation systems to maintain water supply, thusguaranteeing the sustainability of the SPS plantation system.

Conflict between organizations (4.28) was the most important attribute, yet it was not the attribute in the organizational dimension that obtained the lowest score. SPS plantation system involving many parties, including the internal parties (farmers, farmer groups, and associations) and external parties (local regulators, assessors, and exporters). The low incidence of conflicts in the observed areas was discovered through the in-depth interview results. However, organizational management changes, mainly regarding the elections of group leaders, have caused several problems. Despite offering an opportunity for farmers to regenerate their organizational structure, elections may result in inappropriate means of power consolidation and unlikely to deliver accountability to smallholder farmers. This finding was also proved by Mbeche & Dorward (2014) and what influences the extent to which downward accountability is achieved. Kenya Tea Development Agency (KTDA) who stated that weak information flows and institutional development have significantly inhibited the growth of small farmers in developing countries. Transparency of information especially by ensuring that farmers are involved in decision making is required, therefore, farmer organizations can develop downward accountability (Bachke, 2019; Mbeche & Dorward, 2014) access to information and capacity to increase production. I employ panel data from Mozambique to investigate how membership in farmers' organizations impacts smallholders' welfare. Using difference-in-difference estimators that control for unobservable selection bias, I find a positive impact of membership on the marketed surplus (25%).

In contrast with the environmental and organizational dimensions, product quality classification (3.39) was the most important attribute in the technological dimension with the lowest observed score. Physical quality, specifically in terms of fruit size, is an essential requirement that must be met. The export market demands a quality standard in accordance with the SNI 01-3167-1992 on snake fruits, which has a uniform fruit skin color and fruit size, and a maturity level less than 70% (50% to 60%). Furthermore, product quality classification can be used to detect product authenticity visually since SPS has a different fruit size compared with the same cultivar from other regions (Kurniawan *et al*., 2016; Puspitasari, 2016). A further investigation showed there was a tendency of a linear relationship pattern between the altitude of the cultivation area with the produced fruit size. The higher the area, the larger the fruit size and vice versa. The relationship can be influenced by the availability of water sources, temperature, and other factors.

Finally, RAPSalacca is a method that can be used to measure the sustainability status of SPS in a multi-disciplinary, rapid, and cost-effective appraisal, by involving easily-scored attributes. However, Kavanagh & Pitcher (2004) highlighted that the uncertainty aspect is a limitation of this method. The uncertainty is caused by scoring errors due to lack of information, differences in the judgment given by selected respondents, errors in data entry, and high-stress value. Therefore, a Monte Carlo analysis was used in this study to evaluate the impact of random errors on all the dimensions.

CONCLUSION

A rapid appraisal using a multidimensional approach has been widely used to assess agricultural sustainability, though still limited to fishery products. Further studies using this method are necessary since the sustainability assessment of an agricultural product, generally, takes a long time. This method is statistically proven to be able to generate quick results without compromising the accuracy of the data generated. To verify whether this method can be applied to different commodities, RAPSalacca was used in this study to determine the sustainability of SPS as a geographical indication product. This study also enhances the knowledge and insight about the sustainability status of a geographical indication product, specifically Salak Pondoh Sleman. The sustainability status was obtained from the classified sustainability index value, which was analyzed in three subdistricts in Sleman. Among all the three selected dimensions, there is no strong sustainability status for the SPS plantation system. Hence, improvement is necessary to achieve long term sustainability status of SPS as a product with geographical indication certification. By considering the selected sustainability dimensions in this study, improvement actions of each important attribute to its sustainability should be more prioritized, i.e., irrigation system availability, conflicts between organizations, and product quality classification. These attributes can be used by the policy-makers as a consideration in developing policy priorities for supporting the sustainability status of the geographical indication certification of Salak Pondoh Sleman.

ACKNOWLEDGMENT

We thank SEARCA for funding this study through the University Consortium Student Thesis Grant project of USD 500.

CONFLICT OF INTEREST

The author states that this article is original research that has not been published in another journal and that there is no conflict of interest.

REFERENCES

Adenle, A. A., Wedig, K., & Azadi, H. (2019). Sustainable agriculture and food security in Africa: the role of innovative technologies and international organizations. *Technology in Society*, *58*. https://doi.org/10.1016/j.techsoc.2019.05.007

Bachke, M. E. (2019). Do Farmers' organizations enhance the welfare of smallholders? findings from the mozambican national agricultural survey. *Food Policy*, *89*(November), 101792. https://doi.org/10.1016/j.foodpol.2019.101792

Benos, T., Kalogeras, N., Verhees, F. J. H. M., Sergaki, P., & Pennings, J. M. E. (2016). Cooperatives' organizational restructuring, strategic attributes, and performance: The Case of agribusiness cooperatives in Greece. *Agribusiness*, *32*(1), 127–150. https://doi.org/https://doi.org/10.1002/agr.21429

APPENDIX A

No	Attribute	Description	Score
Environment			
1.	Pest Attack	Based on the number of pests in a season: (0) > 40%; (1) 20-39%; (2) 5 - 19%; (3) 0 - 4%	2.10
2.	Regional spatial plan suitability	Based on the suitability of the regional spatial plan in Sleman Regency to the actual SPS plantation: (0) not suitable; (1) suitable	1.00
3.	Land slope class	Land slope class classifications: (0) >40%; (1) 25 – 40%; (2) 15 – 25%; (3) 8 – 15%; (4) 3 – 8%; (5) ≤ 3%	4.79
4.	Chemical fertilizer usage per hectare	Based on the comparison of the used chemical fertilizer per hectare to the recommended dosage: (0) greater; (1) the same; (2) lower	1.98
5.	Land productivity	Based on the relative productivity trends in the last eight years: (0) declining; (1) fluctuating with a declining trend; (2) flat; (3) fluctuating with an increasing trend; (4) increasing	3.09
6.	Irrigation system availability	Based on the irrigation type in most areas: (0) semi-technical irrigation system; (1) technical irrigation system	0.42
7.	Land conversion/land-use change	Based on the land conversion trend in the last eight years: (0) increasing; (1) fluctuating with an increasing trend; (2) flat; (3) fluctuating with a declining trend; (4) declining	2.00
8.	Organic source availability	Based on the organic source availability from crop residues or livestock manure: (0) none; (1) few; (2) lots	1.86
9.	Prediction of land suitability under the risk of climate change	Based on the SPS plantation distribution probability under climate change in 2050: (0) declining; (1) flat; (2) increasing	0.30
Organization			
1.	The intensity of farmer group assistance	Based on the frequency of farmer group assistance to their group members in a year: (0) never; (1) rare/incidental; (2) routine / scheduled	2.00
2.	The intensity of group meetings	Based on a group meeting schedule in a year: (0) never; (1) rare / incidental; (2) routine / scheduled	2.00

No	Attribute	Description	Score
3.	Farmer groups	Based on the number of farmer group establishment in the last five years: (0) declining; (1) fluctuating with a declining trend; (2) flat; (3) fluctuating with an increasing trend; (4) increasing	2.00
4.	Female farmer groups	Based on the number of female farmer group establishment in the last five years: (0) declining; (1) fluctuating with a declining trend; (2) flat; (3) fluctuating with an increasing trend; (4) increasing	2.00
5.	Number of the agricultural extension agents	Based on the number of extension agent development in the last five years: (0) declining; (1) flat; (2) increasing	1.00
6.	Number of professional assistants	Based on the number of professional assistants development in the last five years: (0) declining; (1) flat; (2) increasing	1.00
7.	Conflicts between the organizations	Based on the conflicts between the organizations (economy, production, custom, etc.): (0) still on-going and not yet resolved; (1) still on going and in the process of being resolved; (2) no longer on going because it has been resolved; (3) never existed	3.00
8.	Marketing organization	Based on the availability of institutions/cooperatives that assure its harvest price: (0) none; (1) exists but does not assure prices; (2) exists and assures prices	0.74
9.	Decision making in farmer groups	Based on the parties involved in the decision-making process: (0) unknown; (1) government/facilitator; (2) management; (3) members	2.27
10.	Leadership in farmer group	Based on the leadership performance in farmer groups: (0) unknown; (1) poor; (2) moderate; (3) good	3.00
Technology			
1.	Harvest technique	Based on the harvesting system in the Salak Pondoh Sleman plantation: (0) not harvested; (1) self-harvesting without regulation; (2) self-harvesting with regulation	3.00
2.	Pesticide usage	The types of pesticides used: (0) none; (1) chemical; (2) natural	2.00
3.	Intensity of pesticide usage	Based on the number of pesticide usage per planting session: (0) >5 times; (1) 2 – 4 times; (2) <3 times	2.00
4.	Fertilization technique	The use of fertilizers in one planting season: (0) inorganic fertilizers, (1) organic fertilizers; (2) a combination of inorganic and organic fertilizers; (3) a combination of artificial fertilizers, manures, and plant growth regulator	1.22
5.	Organic fertilizer production technique	Based on the treatment of crop residue: (0) disposed; (1) left standing then buried in the soil; (2) composted by treatment	1.12
6.	Number of machinery and production support equipment	Based on the number of machines and production support equipment in each relative region over the past five years: (0) declining; (1) flat; (2) increasing	1.00
7.	Product quality classification	Based on the quality classification of the produced product in the area: (0) Class 2; (1) Class 1	0.09
8.	Post-harvest treatment	Based on the post-harvest treatment: (0) no treatment; (1) cleaned; (2) cleaned and sorted; (3) cleaned, sorted, and packaged	0.91

Borsato, E., Zucchinelli, M., D'Ammaro, D., Giubilato, E., Zabeo, A., Criscione, P., … Marinello, F. (2020). Use of multiple indicators to compare sustainability performance of organic vs conventional vineyard management. *Science of the Total Environment*, *711*, 135081. https://doi.org/10.1016/j.scitotenv.2019.135081

Brownstein, N. C., Louis, T. A., O'Hagan, A., & Pendergast, J. (2019). The Role of expert judgment in statistical inference and evidence-based decision-making. *American Statistician*, *73*(sup1), 56–68. https://doi.org/10.1080/00031305.2018.1529623

Conti, S., Villari, G., Faugno, S., Melchionna, G., Somma, S., & Caruso, G. (2014). Effects of organic vs. conventional farming system on yield and quality of strawberry grown as an annual or biennial crop in Southern Italy. *Scientia Horticulturae*, *180*, 63–71. https://doi.org/10.1016/j.scienta.2014.10.015

DGIP. (2018). List of Geographical Indication Product. Retrieved April 15, 2020, from https://dgip.go.id/images/ki-images/pdf-files/indikasi_geografis/IG Terdaftar dan Peta Wilayah GI Terdaftar edit September 2018.pdf

Dzikrillah, G. F., Anwar, S., Hadi, S., Agronomi, D., Pertanian, F., Bogor, I. P., & Ipb, K. (2017). Sustainable of rice farming in soreang District of Bandung Regency. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan*, *7*(2), 107–113. https://doi.org/10.19081/jpsl.2017.7.2.107

Erbaugh, J., Bierbaum, R., Castilleja, G., da Fonseca, G. A. B., & Hansen, S. C. B. (2019). Toward Sustainable agriculture in the tropics. *World Development*, *121*, 158–162. https://doi.org/10.1016/j.worlddev.2019.05.002

FAO. (2016). *The State of Food and Agriculture: Climate Change, Agriculture, and Food Security*. Rome.

Fernández-Ferrín, P., Bande, B., Galán-Ladero, M. M., Martín-Consuegra, D., Díaz, E., & Castro-González, S. (2019). Geographical indication food products and ethnocentric tendencies: The importance of proximity, tradition, and ethnicity. *Journal of Cleaner Production*, *241*. https://doi.org/10.1016/j.jclepro.2019.118210

González, N., Marquès, M., Nadal, M., & Domingo, J. L. (2019). Occurrence of environmental pollutants in foodstuffs: A review of organic vs. conventional food. *Food and Chemical Toxicology*, *125*(January), 370–375. https://doi.org/10.1016/j.fct.2019.01.021

Gruda, N., Bisbis, M., & Tanny, J. (2019). Influence of climate change on protected cultivation: impacts and sustainable adaptation strategies - a review. *Journal of Cleaner Production*, *225*, 481–495. https://doi.org/10.1016/j.jclepro.2019.03.210

Irwansyah. (2016). What do scientists say on climate change? A study of Indonesian newspapers. *Pacific Science Review B: Humanities and Social Sciences*, *2*(2), 58–65. https://doi.org/10.1016/j.psrb.2016.09.008

Joshi, N. P., Maharjan, K. L., & Piya, L. (2011). *Effect of climate variables on yield of major food-crops in Nepal: A time-series analysis* (MPRA (Munich Personal RePEc Archieve)). Retrieved from https://mpra.ub.uni-muenchen.de/35379

Kavanagh, P., & Pitcher, T. J. (2004). *Implementing Microsoft Excel Software For Rapfish: A Technique for the Rapid Appraisal of Fisheries Status*. *Fisheries Centre Research Reports* (Vol. 12).

KPIG-SPS. (2012). *Buku Persyaratan Permohonan Pendaftaran Indikasi Geografis: Salak Pondoh Sleman*. (KPIG-SPS, Ed.). Sleman: Directorate General of Intellectual Property.

Kurniawan, M. P., Supartono, W., Sukartiko, A. C., Nuary, R. B., Puspitasari, P. D., Dewi, H. N., & Setyawan, R. (2016). Defining risk assessment severity level of geographical indication product salak pondoh (*Sallaca edulis* cv Reinw) Sleman. In *ICoA Conference Proceedings* (Vol. 3, pp. 189–193).

Mahajan, P. V., Caleb, O. J., Gil, M. I., Izumi, H., Colelli, G., Watkins, C. B., & Zude, M. (2017). Quality and safety of fresh horticultural commodities: Recent advances and future perspectives. *Food Packaging and Shelf Life*, *14*(July), 2–11. https://doi.org/10.1016/j.fpsl.2017.08.001

Mbeche, R. M., & Dorward, P. (2014). Privatisation, Empowerment and accountability: what are the policy implications for establishing effective farmer organisations? *Land Use Policy*, *36*, 285–295. https://doi.org/10.1016/j.landusepol.2013.08.014

Neilson, J., Wright, J., & Aklimawati, L. (2018). Geographical indications and value capture in the Indonesia coffee sector. *Journal of Rural Studies*, *59*(January), 35–48. https://doi.org/10.1016/j.jrurstud.2018.01.003

Nuary, R. B., Sukartiko, A. C., & Maksum, M. (2019a). Modeling the plantation area of geographical indication product under climate change: Salak pondoh Sleman (*Salacca edulis* cv Reinw). *IOP Conference Series: Earth and Environmental Science*, *365*(1). https://doi.org/10.1088/1755-1315/365/1/012020

Nuary, R. B., Sukartiko, A. C., & Maksum, M. (2019b). Towards Sustainable salak pondoh Sleman (*Salacca edulis* cv Reinw) farming system: A socio-economic perspective. In *IOP Conference Series: Earth and Environmental Science* (Vol. 355). IOP Publishing. https://doi.org/10.1088/1755-1315/355/1/012030

Papilo, P., Marimin, Hambali, E., & Sitanggang, I. S. (2018). Sustainability index assessment of palm oil-based bioenergy in Indonesia. *Journal of Cleaner Production*, *196*, 808–820. https://doi.org/10.1016/j.jclepro.2018.06.072

Pitcher, T. J., Lam, M. E., Ainsworth, C., Martindale, A., Nakamura, K., Perry, R. I., & Ward, T. (2013). Improvements to rapfish: A rapid evaluation technique for fisheries integrating ecological and human dimensions. *Journal of Fish Biology*, *83*(4), 865–889. https://doi.org/10.1111/jfb.12122

Prasetyo, R. A., Mu'ín, A., & Wirianata, H. (2017). Kajian curah hujan terhadap produksi salak pondoh di Kecamatan Turi, Kabupaten Sleman. *Jurnal Agromast*, *2*(2), 84–93.

Puspitasari, P. D. (2016). *Karakterisasi Mutu Buah Salak (Salacca zalacca var. zalacca) berdasarkan Asal Usul Geografisnya Menggunakan Principal Component Analysis (PCA)*. Universitas Gadjah Mada.

Suhandy, D., Yulia, M., Kuncoro, S., Rhinaldo, W., Kondo, N., & Ogawa, Y. (2010). The measurement of soluble solids content in snake fruit (*Salacca edulis* Reinw) cv. Pondoh Using A Portable Spectrometer. *IFAC Proceedings Volumes (IFAC-PapersOnline)*, *3*(PART 1). https://doi.org/10.3182/20101206-3-jp-3009.00041

Sukartiko, A. C., Puspitasari, P. D., & Nuary, R. B. (2017). Discrimination of geographical indication products from Yogyakarta Special Region using mineral content. *Industria: Jurnal Teknologi dan Manajemen Agroindustri*, *6*(2), 67–75. https://doi.org/10.21776/ub.industria.2017.006.02.2