

Research Article

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Strategy to improve the sustainability of “porang” (*Amorphophallus muelleri* Blume) farming in support of the triple export movement policy in Indonesia

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Abstract: Porang corms (*Amorphophallus muelleri* Blume) have many uses, high economic value, and high demand from overseas processing industries, making them an export target. However, there are several problems in porang farming, such as closed markets, which affect exports. Therefore, this study examined the sustainability of porang farming as it plays an essential role in supporting the triple export policy. This study was conducted in Wonogiri Regency, Central Java Province, Indonesia. A purposive sampling method was used to select 180 farmers, and the key informants to provide the data included experts, porang associations, and related agency officials. Multidimensional scale (MDS) and qualitative analysis were used to assess the sustainability status and review improvement strategies. Furthermore, environmental, economic, social, institutional, and technological dimensions were analyzed. Multidimensional analysis showed that porang farming is less sustainable. This implies that the indicators in each dimension have little or no support for the cultivation of this plant. The MDS analysis showed 11 indicators sensitive to increasing the sustainability of porang farming, which is a crucial

factor. Therefore, the grade score of this factor is increased to achieve a moderately sustainable progressive strategy. Since the strategy applied between indicators is comprehensive, they do not overlap in their implementation but complement each other in supporting export policies.

Keywords: porang, dimensions, indicators, MDS

1 Introduction

Over the past decade, “porang,” an *Amorphophallus muelleri* Blume plant in Indonesia, has become the major plantation product with high economic value both in domestic and foreign markets [1–4,31]. It is used as a raw material in the food, coatings, cosmetics, medicine, health, textile, paper, and crude oil industries [5–7,11]. Furthermore, porang is processed into glucomannan flour in the food industry. Flour from this corm contains up to 75% glucomannan, the highest compared with that of *Amorphophallus konjac* and *Amorphophallus bulbifer* [6,8]. Glucomannan, which has high economic value, is used as a raw material for food, health, beauty, medicine, and other industries [9]. It is used in Japan for producing *konyaku* and *oden* [10].

The volume of porang exports in Indonesia increased by 40.19% over the 5 years prior to 2017 [11]. Export volume was USD 1.52 million for the period January to February 2021, which was a 160.72% increase compared to that of the previous year. In the same period, the volume of porang export reached 965.5 tons, an increase of 32.31%. The three largest export destinations of porang are China, Thailand, and Malaysia. The export market grew [12] but only 20% of the demand was met. Therefore, there are still opportunities to grow the export market share of porang [13].

Porang cultivation contributes substantially to farmers’ household income [14–16]. It is generally a wild plant that

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grows in forests, unused land, or house yards. In addition, this plant is cultivated on the State Forestry Public Company land (Perhutani) under teak, rosewood, and mahogany plants using an agroforestry system [17]. Figure 1 shows that this plant occurs as monocultures, as an intercrop, and in agroforestry farm lands. Success stories on social media and from individuals about the cultivation of porang have attracted the interest of farmers [18]. However, farmers are reconsidering intensive porang cultivation, because the cost of farming per hectare is relatively high.

One of the porang development areas is located in Wonogiri Regency, Central Java, Indonesia [19]. Sjah et al. [20] stated that the porang is easy to grow and adapt to various agricultural conditions, but the conditions are not optimal. Its successful cultivation depends on the natural conditions, land, innovation, and creativity, which is still low among farmers. There are many obstacles to cultivating porang intensively. The cultivation of Perhutani land should be nurtured with sustainable land management. Furthermore, the expansion of porang cultivation has led to a decrease in rice and corn production due to competition for the use of open land. This increase in crop production requires sustainable land management [21]. The trading structure of porang tends to create an oligopoly market, which presents farmers with marketing challenges [22]. Although porang is a commodity with high economic value that provides great opportunities in the export market, porang exporters do not yet have a direct cooperation contract. Farmers must have documentary proof of record-keeping for the sale to be accepted by the exporter. In addition, quality control has not been optimal, causing several importing countries to cease importing porang from Indonesia. This causes the

price of porang to decrease, resulting in farmers being reluctant to engage in sustainable cultivation of porang. The purpose of this research was to examine the status of and strategy to increase porang cultivation.

2 Materials and methods

The survey method was used [23] based on a case study in Wonogiri Regency, Central Java Province, Indonesia. This region is one of the centers for porang production in the province. The region has a processing industry and an institutional farmer association. However, the relevant agencies have not published data on the number of porang production and cultivation areas. The respondents, which were selected through the purposive sampling method, consisted of 180 farmers from six sub-districts consisting of young farmers aged 25–34 years [24] (7.22%) and old farmers aged ≥35 years (92.78%) from Jatisrono, Karangtengah, Jatiroto, Slogohimo, Jatipurno, and Girimarto, as shown in Figure 2. From each sub-district, 30 farmers were selected using snowball sampling. The respondents in this study were farmers who had been cultivating porang for at least 2 years.

Cross-sectional data were collected from porang farmers as well as key informants from the marketing/processing business sector, field extension officers, relevant government officials, representatives of the farmer associations, and experts from universities. The first stage of this process included in-depth interviews, recording, and observation. Furthermore, more data were collected through a Focus Group Discussion on strategies to achieve sustainability.



Figure 1: Porang cultivation in Wonogiri Regency. Cultivation at 3 days after planting (DAP); cultivation in agroforestry at 5.5 months DAP (plants begin to go dormant); porang corms and “bulbil” from the first year of harvest.

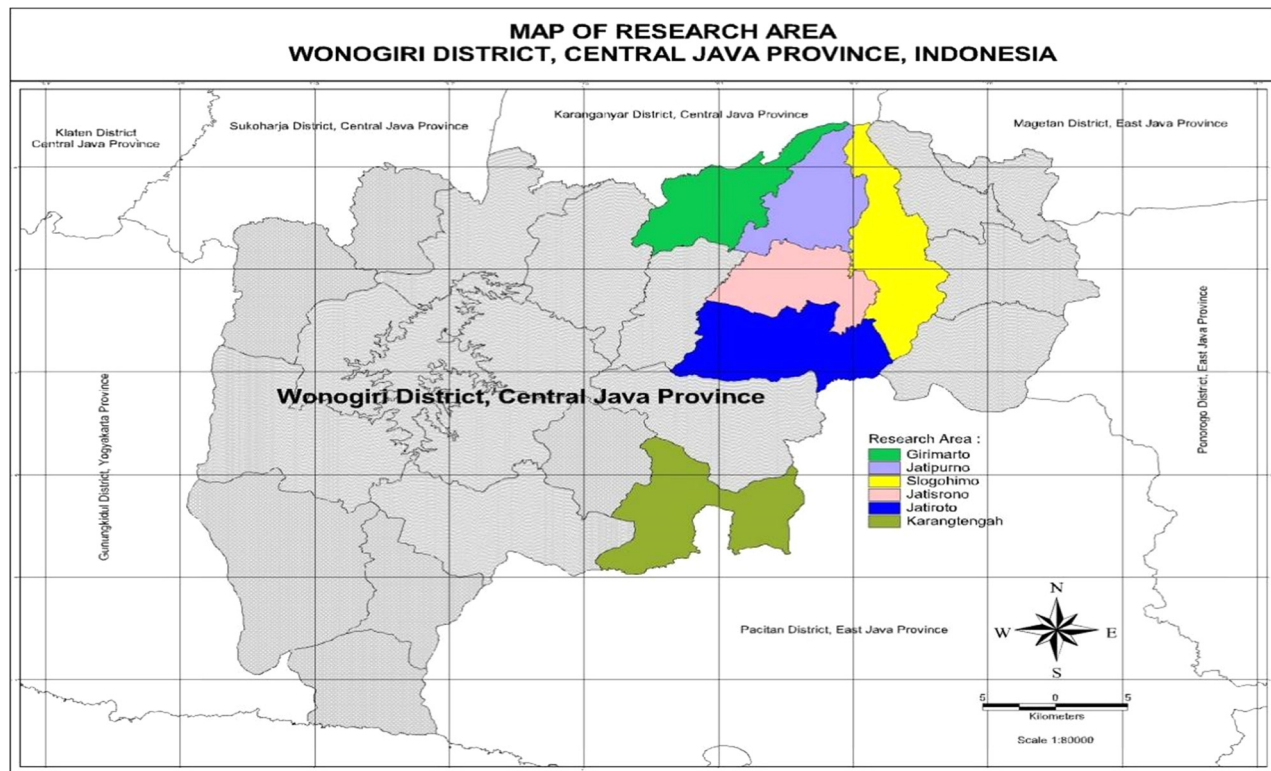


Figure 2: Study location in Wonogiri.

Sustainability status was measured using the rapid method (appraisal) according to [23,25,26]. This approach uses an ordination technique called RAP-Development Farming of Porang (RAP-DEFARMPO). The dimensions, including environmental, economic, social, institutional, and technological, each consisting of 12, 10, 10, 7, and 7 attributes/indicators, are analyzed as in Table 1. The RAP-DEFARMPO used the modal value of each class of indicator.

The sustainability status of porang farming can be determined by looking at the value of the multidimensional scale (MDS). A value between 0 and 25 indicates not sustainable, a value between 25 and 50 indicates less sustainable, a value between 50 and 75 indicates quite sustainable, and a value between 75 and 100 indicates sustainable [26,27]. Other MDS analyses show that attributes/indicators with a root mean square value of more than half are the key factors analyzed quantitatively to determine strategies for improving the farming status [25].

3 Results and discussion

The “porang” plant in Wonogiri Regency has been known since the Japanese colonial era but its cultivation began

only in the past decade. Porang grows wild in forests, riverbanks, yards, gardens, and fields. The reduction in porang corms due to harvesting on these lands, open market prospects, and high demand has prompted farmers to start cultivating porang on open land both in monoculture and intercropping [28]. Observations showed that porang cultivation in Wonogiri has its ups and downs; hence, production data and planted area have not been officially published by the Central Statistics Agency of the regency. In addition, there was a tremendous increase in porang exports during the pandemic [12] leading to open market opportunities. This supported the government in implementing the policy of the Triple Export Movement.

3.1 Porang farming sustainability status

Sustainability analysis from each dimension indicated that the environmental, institutional, and technological dimensions with scores 47.92, 48.65, and 33.54 as shown in Figures 3, 6, and 7, respectively, are less sustainable. Meanwhile, the economic and social dimensions with scores of 51.64 and 51.74 (Figures 4 and 5) are quite sustainable. Therefore, the multidimensional RAP-DEFARMPO analysis resulted in the same weighting of 46.70

Table 1: Dimensions and indicators for measuring sustainability status

Dimension	Indicator	Class	
		Bad	Good
Environmental	Use of frog tubers (bulbil) at the time of planting	0	2
	Availability of bulbil during the growing season	0	2
	The success rate of seedlings from the use of split porang corms	0	3
	Right planting time	0	2
	Cropping pattern	0	2
	Land altitude	0	2
	Fertilizer use	0	3
	Water source	0	3
	Availability of water at the beginning of the growing period	0	3
	Pesticide use	0	2
	Land registration	0	2
	Land conversion	0	3
Economic	Porang corm productivity	0	2
	Porang farming costs	0	2
	Availability of capital	0	2
	Harvest failure	0	2
	Selling price fluctuation	0	2
	The income per year compared to other commodities	0	2
	Land tenure status	0	3
	Feasibility of farming	0	2
	Ease of marketing	0	2
	Market risk	0	3
Social	Adopt Good Agricultural Practices	0	2
	Agricultural Extension	0	3
	The role of agricultural extension workers	0	2
	The intensity of technology counseling and training	0	3
	Family member participation	0	2
	The role of farmer groups	0	2
	The role of the porang association	0	2
	Conflict	2	0
	Farmer's motivation	0	2
	Government assistance	0	2
Institutional	Marketing Institution	0	2
	Institutional capital provision of credit	0	2
	Institutional porang association	0	2
	Farmer capacity development	0	2
	Horizontal collaboration	0	2
	Vertical collaboration	0	2
	Porang development policy	0	2
Technological	Farmers' response to porang cultivation technology	0	2
	Farmers' response to porang post-harvest technology	0	2

(Continued)

Table 1: Continued

Dimension	Indicator	Class	
		Bad	Good
	Availability of post-harvest technology for porang	0	3
	Mastery of GAP technology for porang cultivation	0	2
	Mastery of Porang post-harvest technology	0	2
	Mastery of marketing technology	0	2
	Availability of quality seeds	0	2

Source: [23,26,27]; customized pre-survey findings.

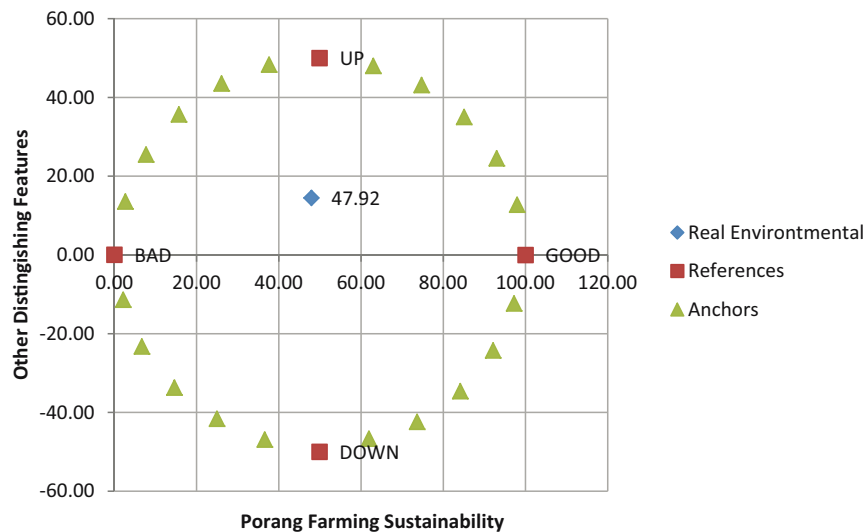
for each dimension, implying lesser sustainability [23,26].

Figure 3 shows that the environmental dimension is less sustainable, indicating lower support for porang farming. The environment could affect the genetic property of this plant [29]. Porang is cultivated by farmers in Wonogiri Regency either as a monoculture or in intercropping with seasonal and annual crops (agroforestry). It is planted alongside woody and fodder plants by farmers in East Nusa Tenggara, one of the efforts to conserve land and water with an agroforestry system [23,30]. The porang cultivation area was obtained by converting forest/garden/dry land to fields. Thus, expanding its portion of open land previously planted with rice/corn crops decreases their production. In addition, this increases pests, fungi, and viruses that reduce the amount of porang corm production [31]. Viruses penetrating through the leaves/stems of plants invade the corms, making them porous and black [32].

The success of porang farming depends on the availability of seeds in sufficient quantities and having good physiological quality. Seed size plays an essential role as it influences the amount of food reserves stored. Larger-weight seeds are of better quality because the food reserves are relatively more [33–35]. “Porang” is a corm with a long life cycle and a bulbil that grows slowly, specifically in the dry season. The dormancy of the seed is broken by soaking [36] and using oligo chitosan [37].

Farmers plant many small-sized seeds due to their limited availability. Porang seedlings in bulbils vary in size with 4–5 months of dormancy [38,39]. Bulbil with large and medium weights produced higher viability in petiole length than the small type. Also, it produces the highest fresh plant weight [28,36,40,41]. Furthermore, a bigger bulbil size produced higher shoot dry weight,

RAP-DEFARMPO Environmental Ordination



Leverage of Attributes

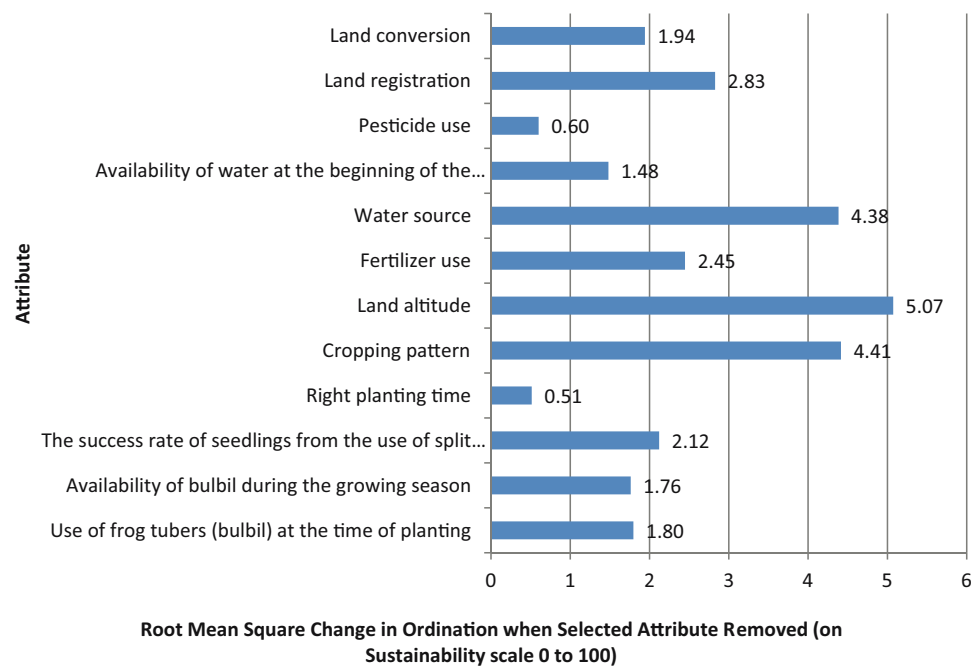


Figure 3: Environmental dimension.

tuber diameter, thickness, and fresh weight of corm at harvest [28].

Porang plants are drought tolerant, but water availability is essential to the success of their cultivation. Therefore, seedlings are recommended at the beginning of the rainy season from October to November [42]. Farmers often experience drought locally known as “betatan” during the rainy season. As a result, the bulbil

that has completely grown withers due to a lack of rain for 10–12 days, which causes crop failure on open land. This “betatan” period mainly occurs in areas less than 400 m a.s.l.

The RMS value of the environmental dimension in Figure 3 shows that land altitude, cropping patterns, and irrigation sources with values of 5.07, 4.41, and 4.38, respectively, are sensitive to increasing sustainability

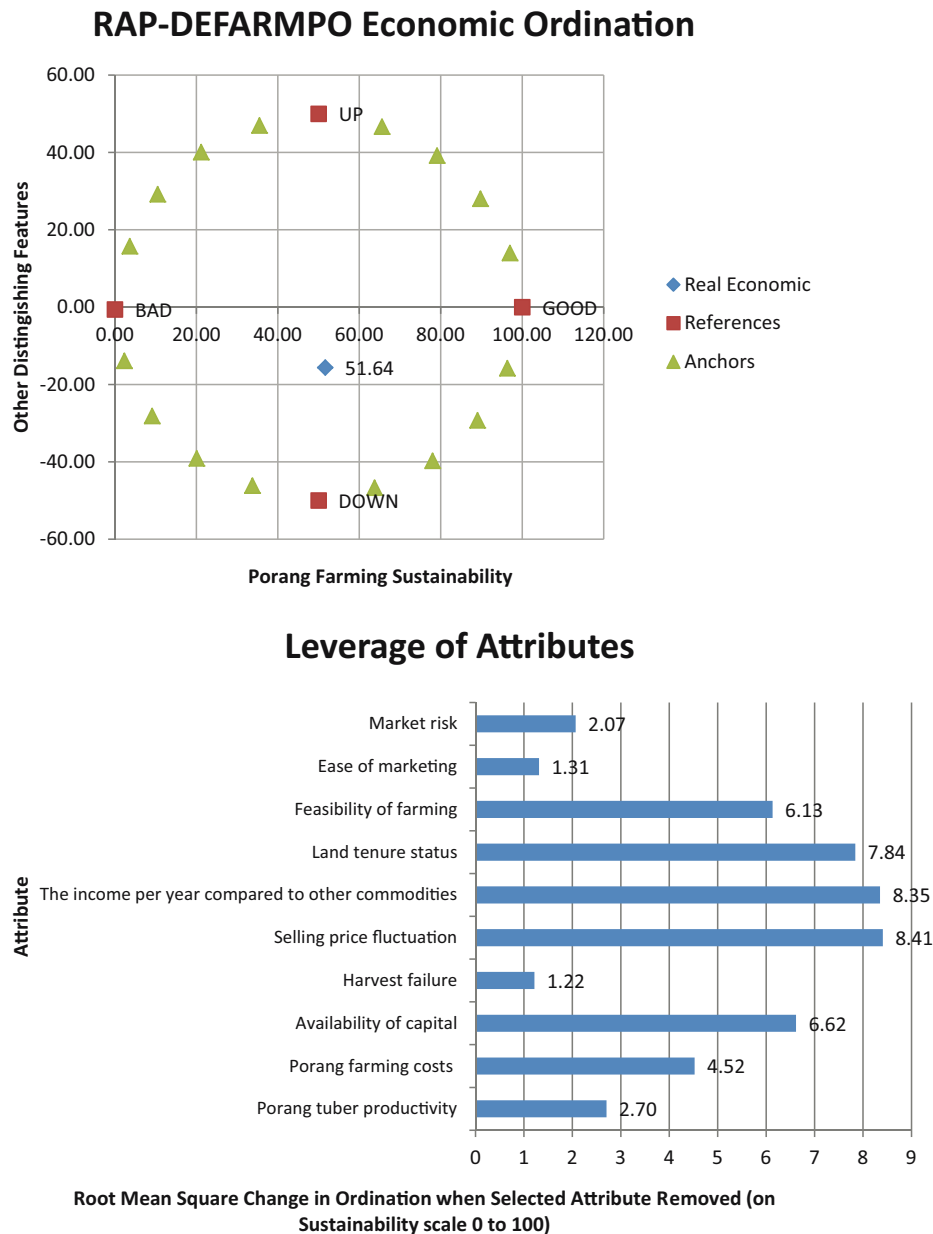


Figure 4: Economic dimension.

status [25]. Planting porang at a higher altitude than 400 m a.s.l will be appropriate given the agro-climatic conditions. The monoculture cropping pattern performed by most farmers has a negative impact on stems. Porang stems are exposed to wind and heavy rain due to a lack of protective plants. Unpredictable weather conditions in the study area pose a high risk. Planting on open land that depends on rain-fed irrigation sources has a high risk of drought during the vegetative growth season. Therefore, a strategy is needed to improve the indicators, making them reasonably sustainable.

The status of the economic dimension shows that it is quite sustainable and supportive of porang farming (Figure 4). This plant has good market prospects, judging by its relatively high selling price. These results are in line with those of Utami [13] and Soedarjo and Djufry [31] where the price of wet porang at the collector level is IDR 11,000/kg in Belimbing Village, Pupuan District, Tabanan Regency, and IDR 10,000–12,000/kg in other areas. However, the price fluctuated due to a decrease in the current condition to IDR 7,000/kg. The weight of one corm is between 2 and 3 kg in the second year and is

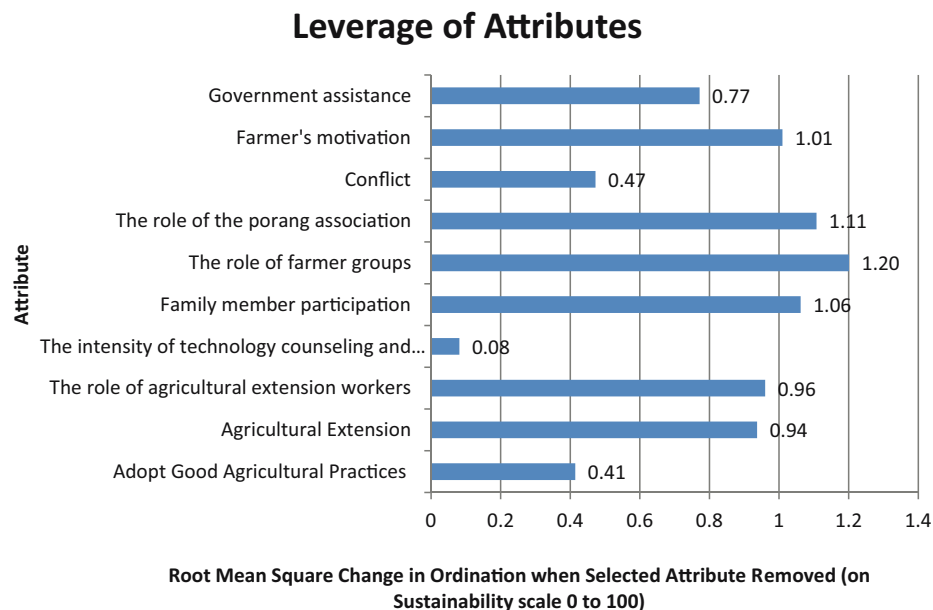
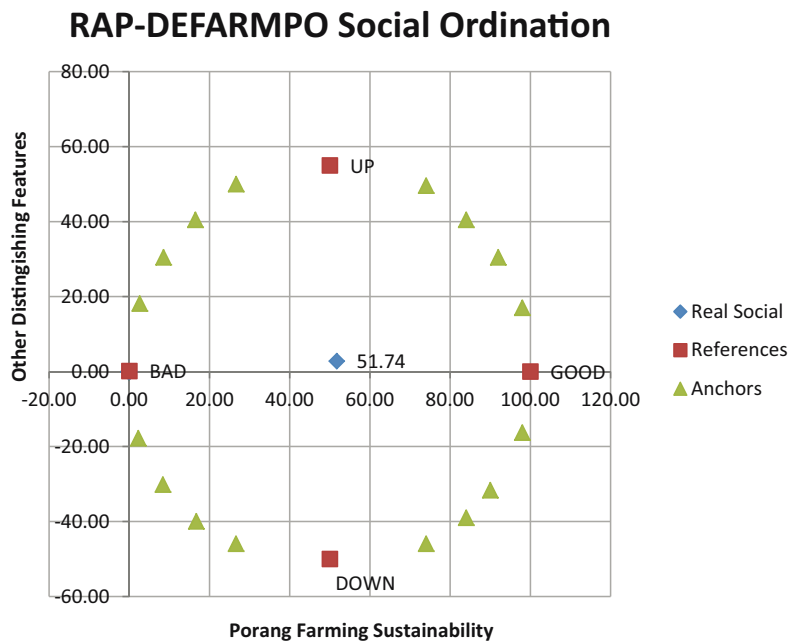


Figure 5: Social dimension.

harvested from 3-year-old porang plants. It also corresponds to the minimum weight requirements set by the exporter [17]. This implies the larger and broader the corm, the heavier the porang, and its glucomannan content [38,40].

The porang market in the study area is a monopsony because only a few exporters buy from farmers selling in groups or independently and in possession of a purchase order from Asia Prima Konjac companies in East Java Propinche. This market condition is risky due to the few buyers and possible unfair competition between farmers.

Therefore, collaboration is crucial in bridging the direct marketing of porang with exporters using agricultural contracts [43].

Porang farming, from an economic point of view, is feasible. However, the initial investment costs are high. This is in line with Hamdhan [44], which states that the initial investment cost for porang farming in a hectare area is IDR 87,660,000 with an average annual income of IDR 260,340,000. Porang from corm and bulbils have higher yields yearly than other crops.

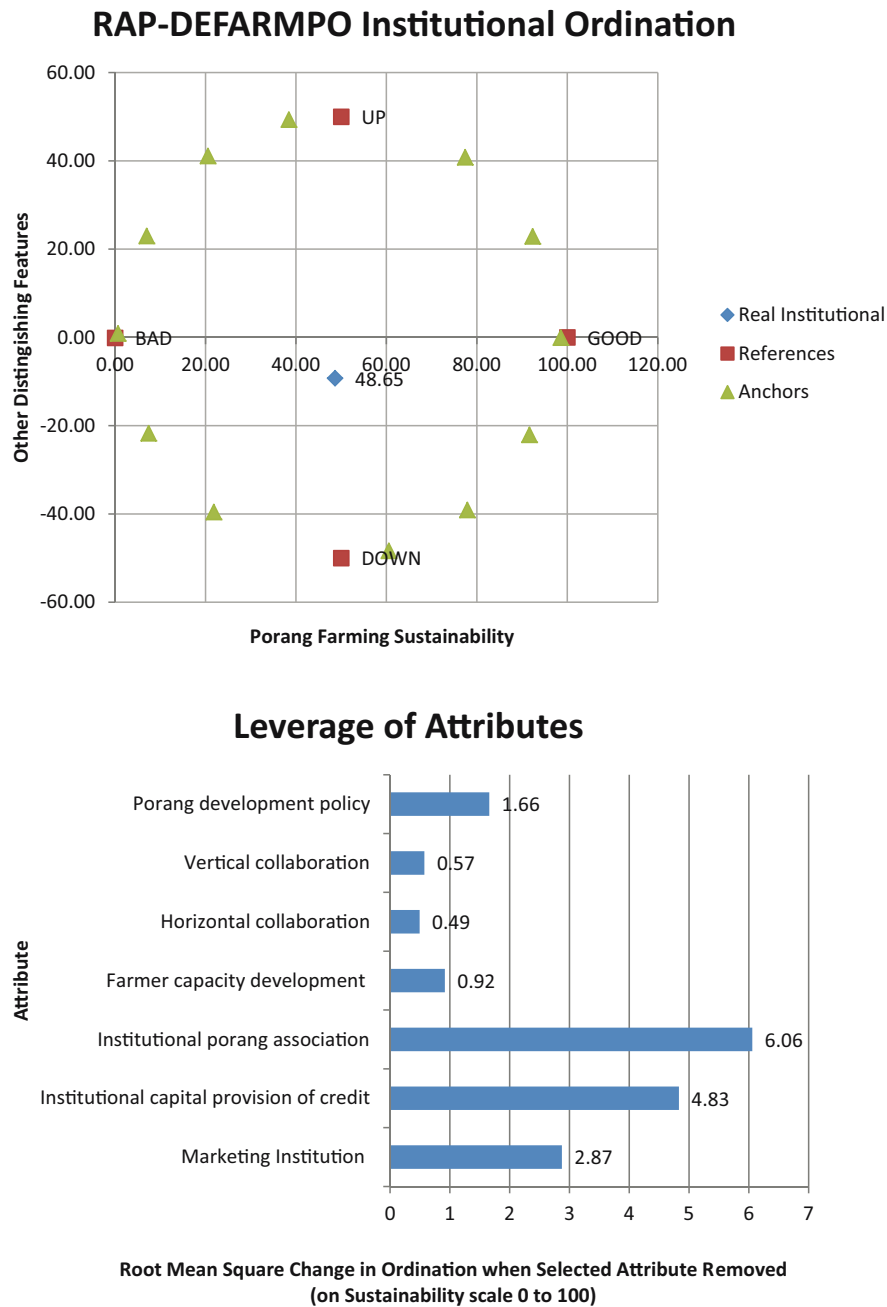


Figure 6: Institutional dimension.

The RMS value of the economic dimension in Figure 4 shows that the fluctuations in selling prices and income per year with values of 8.41 and 8.35, respectively, were sensitive to the increase in sustainability status compared to other commodities [25]. High fluctuations in the selling price of porang and bulbil tuber affected the income received by farmers. In the study period, the price position

of corms and bulbil has decreased in the range of IDR 5,000–7,000/kg and IDR 40,000–50,000/kg, respectively. These corm prices became unstable because there were no sales agreements with exporters/companies.

The social dimension was quite sustainable in supporting porang farming (Figure 5). The National Porang Farmers Association (P3N) supports cultivation and

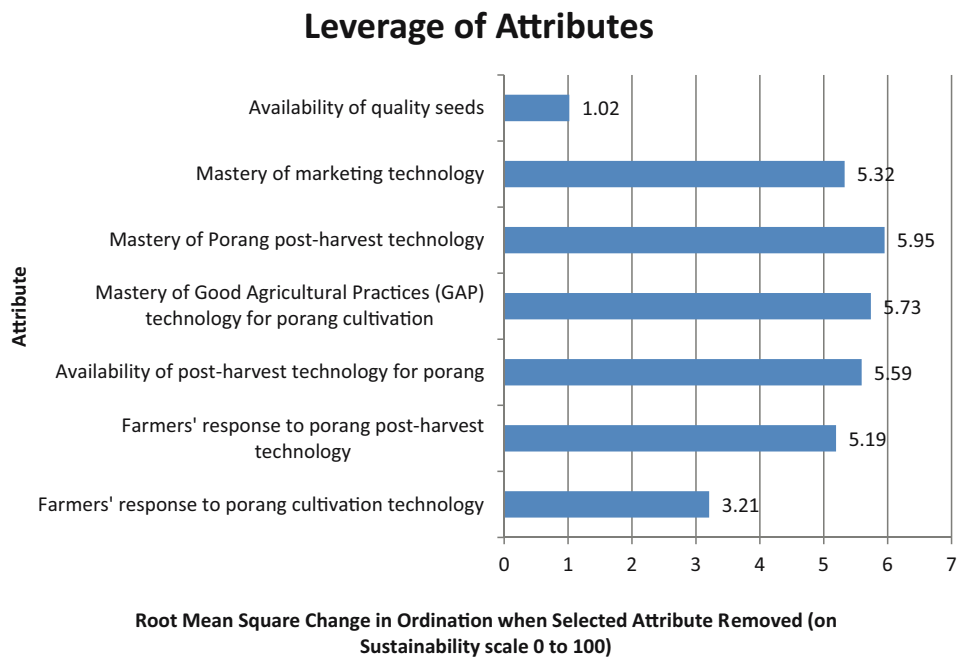
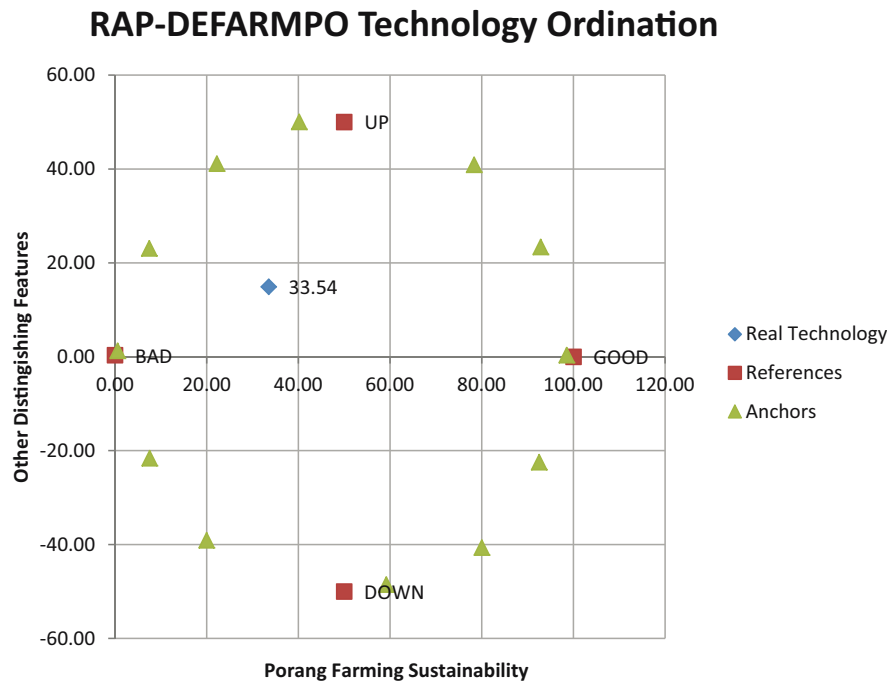


Figure 7: Dimensions of technology.

marketing. A regular meeting was held monthly between farmers to discuss issues from cultivation to marketing of porang. P3N also obtained the same result in South Sumatra [44]. However, the role of farmers' groups was not in developing porang cultivation but increasing the productivity of food crops (rice and corn), which are the primary commodities in the study area.

According to Puspitaningrum and Sumarwoto [45], efforts to increase porang cultivation are made through extension, farmer experience, and information access. The motivation of porang farmers toward cultivation is very high; hence, the successful harvest in the first year has an impact on the expansion of planting land in the second and subsequent years. They are motivated to

Table 2: The goodness of fit of RAP-DEFARMPO

Measurement	Environmental dimension	Economic dimension	Social dimension	Institutional dimension	Technology dimension
Squared correlation (RSQ)	0.954	0.945	0.982	0.946	0.950
S-Stress	0.132	0.133	0.098	0.144	0.139

increase porang production. However, high motivation in farming requires the support of family members.

The RMS values for the role of farmer groups and porang farmer associations of 1.20 and 1.12 (Figure 5), respectively, indicate that they play an essential role in increasing the sustainability of porang cultivation. Farmers are inseparable from institutions, which influence their knowledge, insight, skills, and perspectives in managing their farms [46]. These institutions motivate farmers to cultivate porang.

Figure 6 shows that the institutional dimension is less sustainable, indicating that it does not support porang farming. The triple export policy has not provided significant support to the development of porang farming in terms of subsidies, farm credit, marketing institutions, and facilitation of cooperation between porang farmers and stakeholders. The cooperation between porang farmers is still coordinated by P3N. Similarly, the capacity development of farmers in porang farming remains under the technical guidance of P3N. The institution was officially formed at the regency level.

The RMS value of the institutional dimension in Figure 6 shows that the porang farmer association and the capital institutions for providing credit are sensitive to the sustainability of porang cultivation. The organizational structure of the community association needs to be improved to meet the needs and dynamics of porang farmers in the Wonogiri Regency. Likewise, capital institutions, especially the banking sector, provide working capital for the people's business credit scheme "Kredit Usaha Rakyat." The credit schemes with low-interest rates help porang farmers expand their business.

Figure 7 shows that the technology dimension is less sustainable, implying that it does not support porang farming. This plant is marketed in the form of wet corms to Asia Prima Konjac companies or the porang exporter in East Java. The processing of porang corms to make glucomannan adds value, which benefits exporters [38,40] with a high selling price of about IDR 500,000/kg. However, the technology of converting wet corms into glucomannan has not been practiced by farmers and is

Table 3: Differences in the sustainability index value of RAP-DEFARMPO and Monte Carlo analysis

Sustainability dimension	MDS	Monte Carlo	Difference
Environment	47.92	47.84	0.06
Economy	51.64	51.14	0.50
Social	51.74	51.31	0.43
Institutional	48.65	48.36	0.29
Technology	33.54	33.73	0.19

Table 4: Strategy for increasing the sustainability of “Porang” (*A. muelleri* Blume) farming in supporting triple export movement policy

Indicator	Strategy to increase class score
Land altitude	Porang cultivated in areas with suitable agro-climatic conditions more than 450 m a.s.l. Furthermore, farmers identify areas that meet the vegetative and generative growth requirements, such as hilly and mountainous regions. Porang grows well on lightly textured soils rich in nutrients [38,52,53]
Cropping pattern	Polyculture planting with annual crops minimizes the risk of damaging porang plants due to heavy rains, strong winds, and drought. Moreover, polyculture cropping maintains soil moisture and suits the agro-climate of porang plants
Water source	Most of the irrigation sources for porang cultivation are rain-fed. This makes cultivation prone to drought during the vegetative growth period. Therefore, the construction of ponds at the planting site is essential to ensure water availability. The bottom surface of reservoirs is covered with water-resistant material to prevent water from seeping into the ground [54]
Selling price fluctuation	The high fluctuations in selling prices need to be reduced for stability. This can be achieved through contract farming with porang exporters in East Java Province. Furthermore, the government and P3N should facilitate a relatively strong farmer's position in the contract farming arrangements
The income per year compared to other commodities	Income from porang farming can be improved by optimizing the planting and value-addition systems. Planting should be performed depending on the objectives to be achieved from the harvest, either in bulbs for seeds, bulbils, or bulbs that meet the requirements to be sold to exporters. Closely spaced planting systems will produce corms as seeds for the next growing season. Corms planted in the following growing season use medium spacing (80 cm × 80 cm) or (100 cm × 100 cm) to produce a tuber with a minimum weight of 2 kg suitable exporting. Furthermore, value-addition should be performed by chopping porang corms into chips. This increases the revenue by 15–20% compared to corms sold wet
The role of farmer groups	Farmer groups, which are the lowest in the institution at the farmer level, have a strategic role of increasing the capability [54] and management of porang farming. Farmers' groups play an active role in increasing productivity, providing seeds, marketing, and establishing cooperation with porang stakeholders. These farmers' groups also plays an essential role of communicating the aspirations and interests of farmers to the government, which is a major decision-maker for the development of porang in the Wonogiri Regency.
The role of the porang farmer association	P3N plays an essential role in developing porang farming in the Wonogiri Regency. The role of P3N to establish cooperation with exporters or the porang processing industry to accommodate farmers in marketing porang corms needs improvement. Market certainty will convince farmers to farm on a broader scale. Another role of P3N is to coordinate the registration of members' land used for porang farming. Integrated land management is one of the requirements if porang corms are sold to exporters
Institutional porang farmer association (P3N)	P3N needs to be organized at the sub-district level to increase its closeness and accessibility to porang farmers. The organizational structure and its primary functions should be adjusted to the dynamics of the growing group, following the demands of its members. The selection of the association's board of directors should be adjusted to the competencies appropriate to their primary duties and functions
Institutional capital provision of credit	According to the people's business credit program (KUR), banking institutions and agricultural cooperatives are essential in providing porang farming loans with interest rates according to the people's business credit program (KUR). The capital institutions should disseminate information on credit facilities to P3N. This will increase the motivation of porang farmers because they currently have limited capital
Mastery of Porang post-harvest technology	Post-harvest handling technology to increase added value in chips, flour, and glucomannan needs to be introduced. Technology to remove oxalic acid in porang corms is essential for direct usage as food. This strategy needs to be synergized with expanding the marketing network for these products. Furthermore, the chips, flour, and glucomannan products market is specifically for buyers
Mastery of GAP technology for porang cultivation	Porang farming requires agroecology that meets the growing requirements of soil suitability, climate, irrigation, land preparation, seed preparation, fertilization, pest and disease control, and maintenance [55]. GAP technology should be introduced to farmers during the whole process, from land preparation to harvesting to minimize the risk of failure

Table 5: The results of leveraging 11 indicators on all dimensions of sustainability

Dimension	MDS	Leverage value		
		MDS	S-Stress	RSQ
Environment	47.92	54.15	0.14	0.95
Economy	51.64	60.53	0.14	0.95
Social	51.74	66.10	0.13	0.95
Institutional	48.65	52.51	0.15	0.95
Technology	33.54	52.12	0.14	0.95

expensive. The value-addition process takes approximately 10 weeks after harvest [47].

Good Agricultural Practices (GAP) indicated that farmers did not fully implement porang cultivation technology. Crop failure due to seeds or plants that have grown completely dead because of drought in the “betatan” rainy season is often experienced by porang farmers on the open land of less than 450 m a.s.l. The corms were also affected when the plant is flooded due to excess water; hence, a sound drainage system is needed.

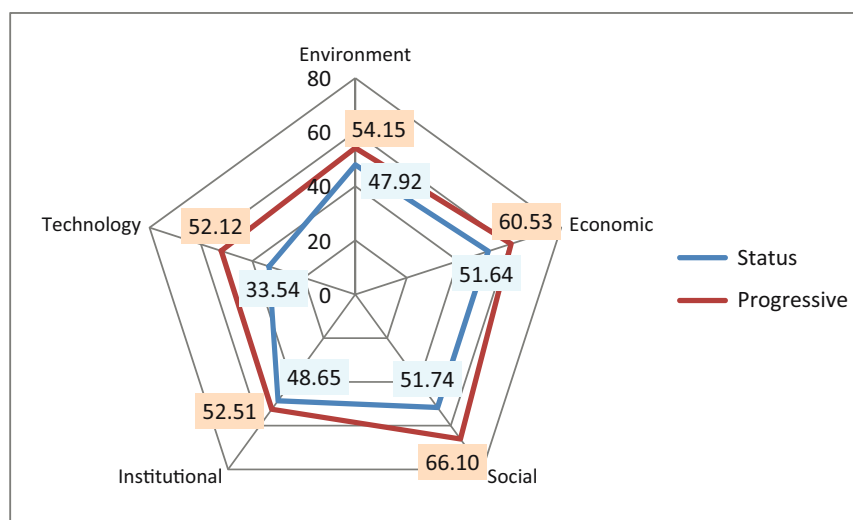
The RMS value of the technological dimension in Figure 7 shows that the mastery of post-harvest porang technology and GAP for cultivation is sensitive to sustainability. Farmers did not process porang corms due to limited technological mastery. Furthermore, there was a significant difference in their prices with increased added value [44,48,49]. Porang tubers cannot be eaten only by

boiling or making flour. Oxalic acid needs to be removed so that porang does not cause an itchy effect on the throat or mouth [4]. Porang plants require agro-climatic conditions suitable for growth. The application of inorganic fertilizers is limited to increasing the glucomannan content and meeting the export requirements.

3.2 The goodness of fit analysis

R^2 and S -stress values are used to analyze goodness of fit. The sustainability index estimation model in the MDS analysis is good, adequate to use, and has high accuracy when R^2 is close to 1 and the S -stress value is less than 0.25 [50,51]. The results of the RAP-DEFARMPO analysis, comprising S -stress < 0.25 and R^2 close to 1, indicate a good fit (Table 2). This means that the five dimensions in the RAP-DEFARMPO model were appropriately used.

The random error rate of the RAP-DEFARMPO model was estimated using Monte Carlo analysis on all dimensions of sustainability at a 95% confidence level. The Monte Carlo analysis showed no significant difference ($p > 0.05$) between the results of the RAP-DEFARMPO and the Monte Carlo test (Table 3). These indicate that the level of confidence in each dimension's total index (multidimensional) is more than 95% [51]. Therefore, the MDS analysis model is adequate to predict the sustainability of porang cultivation in supporting a triple export policy.

**Figure 8:** Kite diagram of sustainability and progressive status.

3.3 Strategy to improve sustainability of “porang” (*A. muelleri* Blume) farming in support of the triple export movement policy

The export activities of the porang are essential to support continuous production, which enhances sustainability. A total of 11 indicators leverage all dimensions based on the RMS value that can progressively improve sustainability status. Table 4 shows that the application of progressive strategy increases the score of one class. Table 5 shows that these indicators are increased by one score in each class to achieve quite sustainability, and the changes are seen in Figure 8.

The strategy for each indicator that is leveraged is inseparable from the implementation of the others. The synergy of implementation between indicators is needed to achieve optimal conditions to improve sustainability. Therefore, government support and facilitation are essential to achieve an increase in the score of 1 level, which enhances the policy of the triple export movement.

4 Conclusion

Porang is one of the favorite export commodities on the rise, but from a farming perspective, it is not sustainable. Therefore, its export activities are important to support continuous production and enhance sustainability. The MDS analysis results showed 11 indicators that are sensitive to increasing the sustainability status. The strategy is based on increasing the score by one level. Furthermore, the government, P3N, farmer groups, exporters, and credit provision institutions synergize to implement strategies for improving the sustainability status of porang cultivation.

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Author contributions: EWR: conceptualization, methodology, data analysis, original draft, project administration; HI: data curation, data analysis and review; M: supervision, original draf, review and editing.

Conflict of interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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