Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2026; 26(3): 29036-29053 https://doi.org/10.18697/ajfand.150.26265

Date	Submitted	Accepted	Published
	15th August 2025	10th March 2026	9th April 2026

ARROWROOT DEVELOPMENT AND THE PERCEPTIONS OF ITS SUSTAINABILITY STATUS FOR FOOD SECURITY IN INDONESIA

Irianto H[1,2*], Rahayu ES[1], Handayani SM[1], Setyowati[1], Sundari MT[1] and F Widadie[1]

Heru Irianto

*Corresponding author email: heruirianto@staff.uns.ac.id
ORCID: https://orcid.org/0000-0002-6228-899X - Irianto H
ORCID: https://orcid.org/0000-0002-4967-0780 - Rahayu ES
ORCID: https://orcid.org/0000-0003-2804-7938 - Handayani SM
ORCID: https://orcid.org/0000-0002-5525-1515 - Setyowati
ORCID: https://orcid.org/0000-0002-2903-1498 - Sundari MT
ORCID: https://orcid.org/0000-0002-7248-3211 - Widadie F

[1]Department of Agribusiness, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, 57126, Indonesia

[2]The Center for Micro, Small, and Medium Enterprises and Cooperative Studies, Universitas Sebelas Maret, Surakarta, 57126, Indonesia

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

The decline in rice availability due to repeated crop failures has occurred recurrently in Indonesia. Arrowroot (*Maranta arundinacea*) tubers, which are rich in carbohydrates and gluten-free, have the potential to serve as an alternative to rice or as a complementary ingredient in rice-based products, thereby contributing to the enhancement of sustainable national food security. This study aimed to evaluate the sustainability of arrowroot farming in Kulon Progo Regency, Yogyakarta, one of Indonesia's key arrowroot-producing regions. Research was conducted from July to November 2023 using a mixed-method approach that combined quantitative surveys of 62 farmers and five key informant interviews involving one representative from the Kulon Progo Regency Agriculture Office, two representatives from the Sub-district Agricultural Extension Centers, and two representatives of the arrowroot cultivation and processing farmer groups. Sustainability status was assessed using Multi-Dimensional Scaling (MDS) through a modified Rapid Appraisal Technique Arrowroot (RAP-ARR), which considered four dimensions: environmental, economic, social and technological. The findings revealed that the overall sustainability status of arrowroot farming is currently categorized as "less sustainable." Several key attributes were identified as critical points for improvement. In the environmental dimension, major challenges include pest and disease control, water conservation, and soil condition. The economic dimension requires strengthening farming experience and enhancing the government's role in supporting export opportunities. Socially, the effectiveness of development policies, the presence of marketing institutions, and farmer responsiveness to technology adoption remain weak. Meanwhile, in the technological dimension, cultivation methods and the use of organic fertilizers require significant attention. These results highlight that although arrowroot has promising potential as a non-rice carbohydrate source, realizing its role in strengthening food security depends on multi-dimensional improvements. Targeted interventions across environmental management, farmer capacity building, institutional support, and technological innovation are essential for enhancing the sustainability of arrowroot farming. Strengthening these dimensions could position arrowroot not only as a viable alternative to rice but also as a strategic commodity in Indonesia's sustainability-based food industry development.

Key words: Agricultural diversification, food security, gluten-free flour, non-rice alternatives, RAP-ARR, sustainability

Citation: Irianto H, Rahayu ES, Handayani SM, Setyowati, Sundari MT and F Widadie Arrowroot Development and the Perceptions of its Sustainability Status for Food Security in Indonesia. *Afr. J. Food Agric. Nutr. Dev.* 2026; **26(3):** 29036-29053. https://doi.org/10.18697/ajfand.150.26265

INTRODUCTION

Climate change due to increased environmental degradation, greenhouse gas (GHG) emissions, and global warming has already resulted in declining global crop yields and food availability [1]. By 2050, climate change will reduce agricultural productivity (by 2% to 15%) and increase food prices (by 1.3% to 56%) worldwide [2]. By 2030, climate change is also expected to reduce food production in South Asia for rice, wheat and cereal grains by 4%, 11% and 7%, respectively. Further impacts of these productivity declines are expected to pressure food prices and security. Prices of rice, wheat and other grains are expected to increase much faster, by 10%, 25% and 45%, respectively [3].

Various food crops, especially rice, are the staple food for almost half of the world's population [4]. In fact, in Indonesia, rice is the staple food for most people [5-6]. The declining rice availability due to crop failure, as in early 2024, has happened repeatedly in Indonesia [7]. As a result, rice prices have soared. This shortage of food supply, particularly rice, has occurred in recent years. On the one hand, this phenomenon not only requires the government to strive for the availability of rice, but also allows non-rice food sources to emerge as a substitute for rice or just a companion to processed rice food. Some foods that can be a substitute for rice or a companion to processed rice are corn, cassava and tubers such as arrowroot [8,9,10]. Arrowroot (*Maranta arundinacea*) is one of the tubers that can be processed into flour with high carbohydrate content [11]. The nutritional content and chemical properties of arrowroot flour are similar to wheat flour, which is easily digested, with digestibility reaching 90%, but does not contain gluten [12]. Although at present, the proportion of consumption is still very low, the characteristics of arrowroot tubers allow it to become an alternative to rice and a companion to processed rice and functional foods [13,14].

To date, farmers have not cultivated arrowroot properly and optimally. Although it can contribute to farmers' income, most arrowroot plants are only planted in the fields or yards without significant maintenance [10]. Based on such potential and opportunities, this study examines the sustainable dimensions of arrowroot tuber farming in Kulon Progo Regency, one of the arrowroot-producing regions in Yogyakarta Special Region.

MATERIALS AND METHODS

Research location and Time

This research was conducted in Kulon Progo Regency, Yogyakarta Special Region Province of Indonesia. Kulon Progo Regency is one of the two districts that produce arrowroot plants. In Kulon Progo Regency, arrowroot is mainly cultivated in two villages, namely Hargorejo Village in Kokap District and Sendangsari Village in

ajfand Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Pengasih District (Figure 1). The research was conducted from July to November 2023.

Research Design

This study employed a mixed-methods approach, combining quantitative and qualitative methods. The qualitative research involved key informants acting as experts and was conducted using a one focus group discussion (FGD) technique to determine the sustainability dimensions and attributes assessed, as well as to formulate sustainability strategies for arrowroot farming. The number of experts considered sufficient to achieve a high level of precision ranged from three to seven individuals, provided that these experts possessed a deep understanding of the object of study and the research location [15,16].

Population and Sampling

The population of arrowroot farmers has not been well documented; therefore, its exact size is unknown. Consequently, the sample size was determined using the Lemeshow formula, with a Z value of 1.96, a P value of 20%, and a margin of error (d) of 0.1 [17].

$$n = \frac{z^2 \ x \ P \ x \ (1 - P)}{d^2}$$

$$n = \frac{(1.96)^2 \ x \ 0.2 \ x \ (1 - 0.2)}{(0.1)^2}$$

$$n = \frac{0.614}{0.01}$$

$$n = 61.47 \ \approx 62$$

Thus, the total sample of this study consisted of 62 arrowroot farmers selected using snowball sampling. Meanwhile, the qualitative study involved five key informants [15,16]. The five informants consisted of one representative from the Kulon Progo Regency Agriculture Service, two representatives from the Sub-district Agricultural Extension Center (one from each research sub-district), and two representatives from the Starch Cultivation and Processing Farmer Group (one from each sub-district). The information collected focused on sustainability-related attributes across environmental, economic, social and technological dimensions, including farming practices, institutional support, technology adoption, marketing conditions, and constraints in arrowroot farming development. Data were collected through direct observation, interviews, literature review, documentation and FGD [18].

ajfand Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

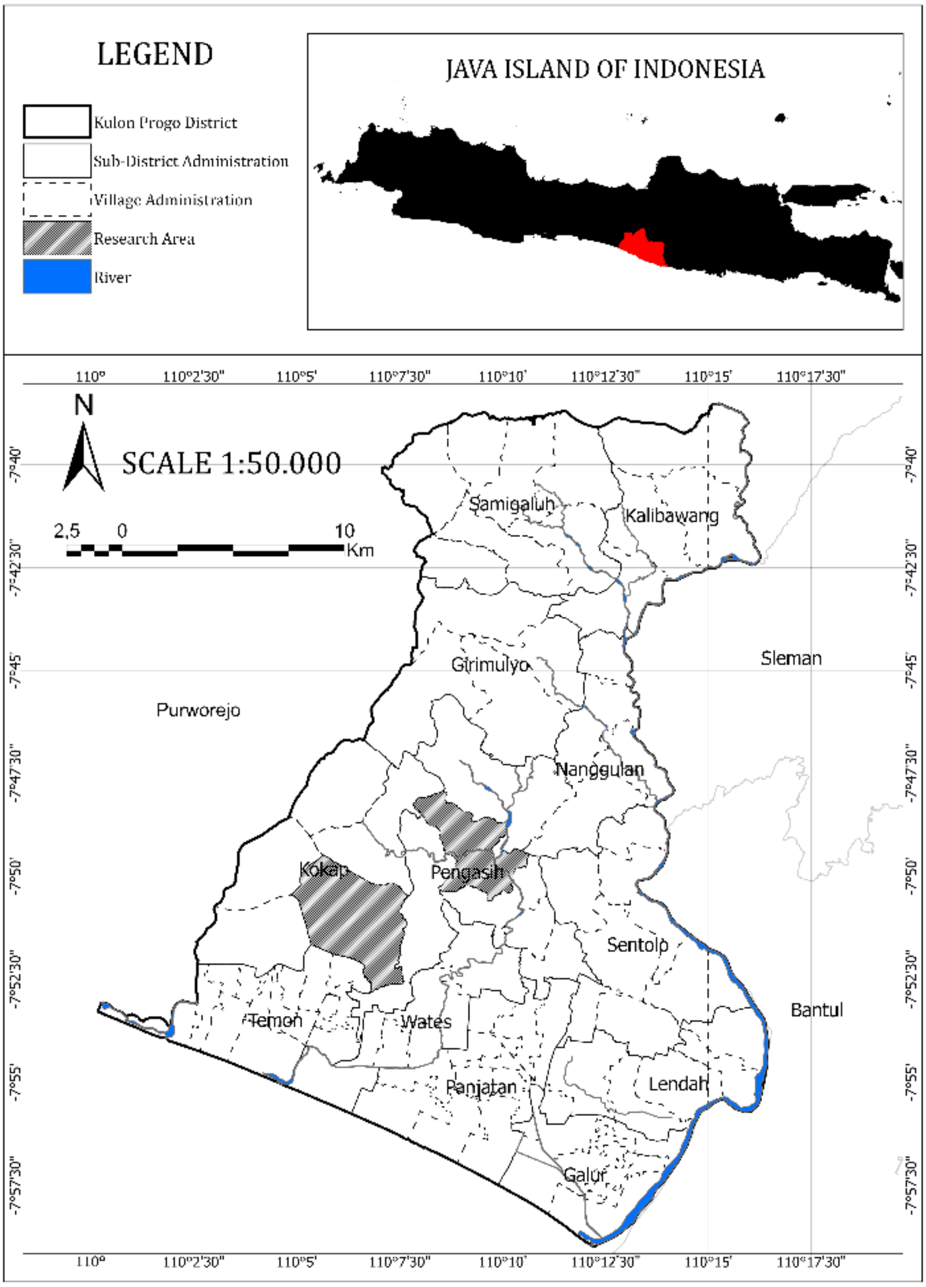


Figure 1: Map of Kulon Progo Regency, Yogyakarta Special Region of Indonesia

Data analysis

This study employed a multidisciplinary rapid appraisal method, namely Multidimensional Scaling (MDS) analysis. The purpose of using MDS analysis was to assess the sustainability status of each dimension in order to identify imbalances among dimensions. The software technique commonly used for this approach is Rapid Appraisal for Fisheries (RAPFISH), which is applied to determine measurable indicators. In RAPFISH, sustainability is quantitatively described by a set of criteria

ajfand Since 2001 AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

defined through numerical analysis using a set of scored attributes [19]. In this study, the determination of the criteria refers to the identification of sustainability dimensions and their attributes. In this process, the role of informants was crucial, therefore, these criteria were established through the FGD technique. The principles of RAPFISH analysis include: (1) a rapid assessment method to evaluate the sustainability status of an object based on a number of attributes, (2) attributes can be redefined or replaced according to the availability of information, (3) a multi-criteria decision-making method based on a MDS approach, and (4) the use of ordination techniques to determine sustainability status [20,21].

In this study on the sustainability analysis of arrowroot farming, the software technique used was a modification of RAPFISH into a Rapid Appraisal technique for arrowroot development, referred to as Rapid Appraisal Arrowroot (RAP-ARR) [22,23].

This research used four sustainability dimensions, namely environmental, economic, social, and technological, with the attributes of each dimension determined through modifications based on previous research findings and field conditions identified during the FGD, as presented in Table 1. Each attribute of each dimension was measured based on scores that refer to related references and expert input [18,23]. Then, the sustainability status of arrowroot farming was determined based on the sustainability index with categories as presented in Table 2. Meanwhile, the improvement of sustainability status is seen from the key factors (attributes) of the root mean square from the highest to half of the value of each sustainability dimension [18,24,25]. Meanwhile, improvements in sustainability status were evaluated based on key factors or attributes identified from the root mean square values, ranked from the highest down to half of the value of each sustainability dimension, derived from leverage analysis [22,23,26].

RESULTS AND DISCUSSION

Multidimensional sustainability

The qualitative data obtained from key informants and the FGD were used to identify sustainability attributes and contextual factors influencing arrowroot farming. The discussion involved representatives from the Agriculture Office, agricultural extension centers, and farmer groups. The information collected included cultivation practices, pest and disease management, institutional support, marketing conditions, technology adoption, and constraints faced by farmers in developing arrowroot farming. These qualitative insights were subsequently used to validate the scoring of sustainability attributes in the multidimensional scaling (MDS) analysis.

In this study, the term “development” refers to sustainability-oriented improvement pathways derived from leverage attributes identified through multidimensional

Since 2001
ajfand
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

scaling analysis, rather than the implementation of direct intervention programs. Based on the sustainability index reference, the research results on the sustainability of arrowroot cultivation development show the following for each dimension. In the environmental dimension, as presented in Figure 2, the results of the ordination of the sustainability of arrowroot crop development have an index of 36.14, meaning less sustainable. Meanwhile, the R^2 value is 94.8%, with a stress value of 0.15. This result shows that 94.8% of data variation can be explained by the factors included in the multidimensional scaling (MDS) model using the modified RAPFISH approach (RAP-ARR). Thus, judging from the R^2 value and the stress value, the MDS results of this environmental dimension show a good model to capture environmental problems, so that the environmental dimension analysis does not require additional attributes.

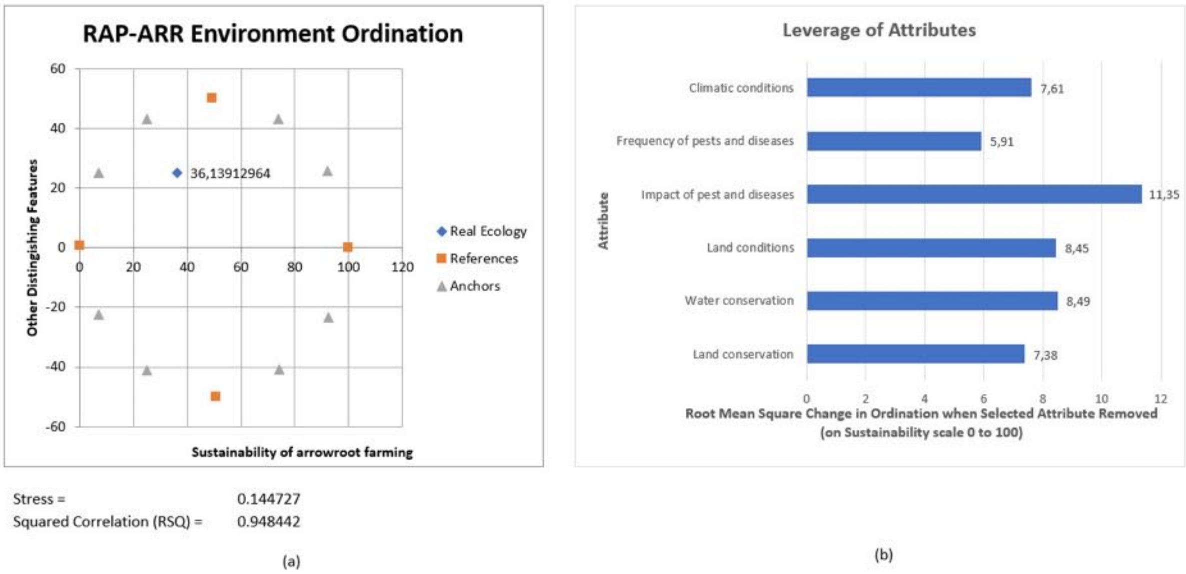


Figure 2: Sustainability in terms of the environmental dimension

The results of the ordination of the sustainability of arrowroot plant development in the economic dimension have an index of 42.98, meaning it is less sustainable.

These results indicate that 94.9% of data variation can be explained by the MDS model using the modified RAPFISH approach (RAP-ARR). Based on the R^2 and stress values, the MDS ordination for the economic dimension demonstrates good model performance in capturing economic sustainability conditions, indicating that no additional attributes are required (Figure 3).

Since 2001
ajfand
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

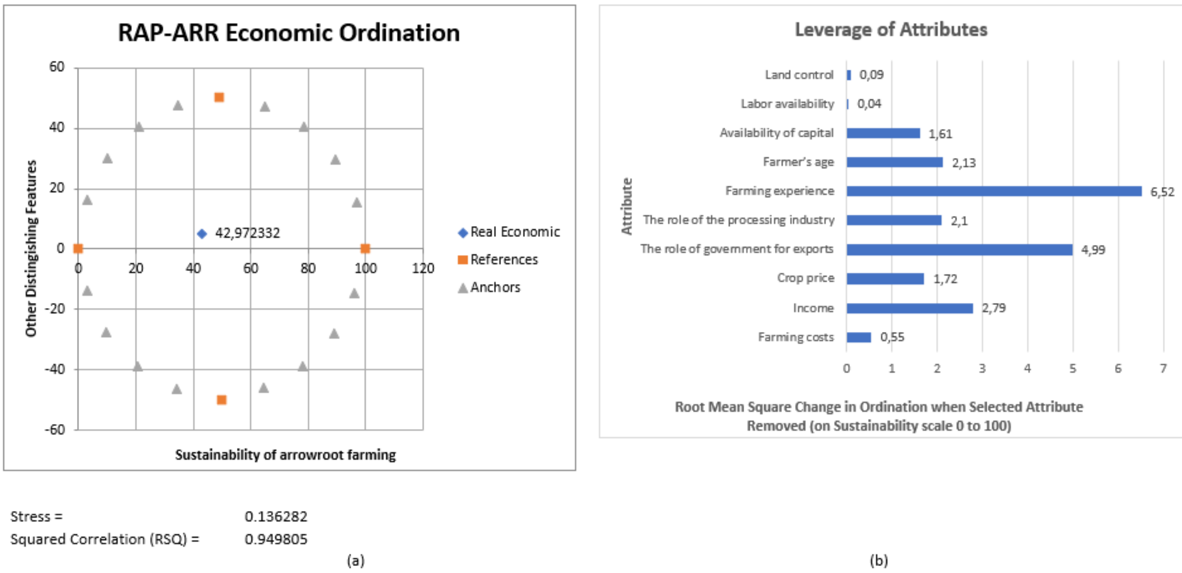


Figure 3: Sustainability in terms of the Economic dimension

In the social dimension, as presented in Figure 4, the results of the ordination of the sustainability of arrowroot plant development have an index of 48.27, which means it has a less sustainable status. At the same time, the R^2 value is 94.9%, with a stress value of 0.14. This result shows that 94.9% of data variation can be explained by the factors included in the model. Thus, judging from the R^2 value and the stress value, the results of this social dimension MDS show a good model to capture social problems so that the analysis of the social dimension does not require additional attributes.

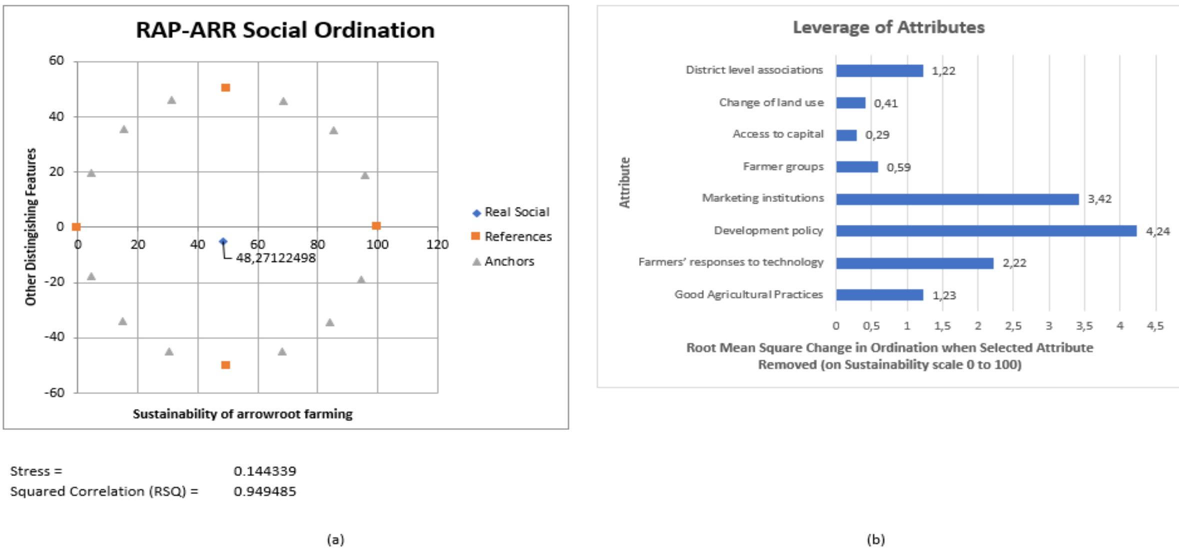
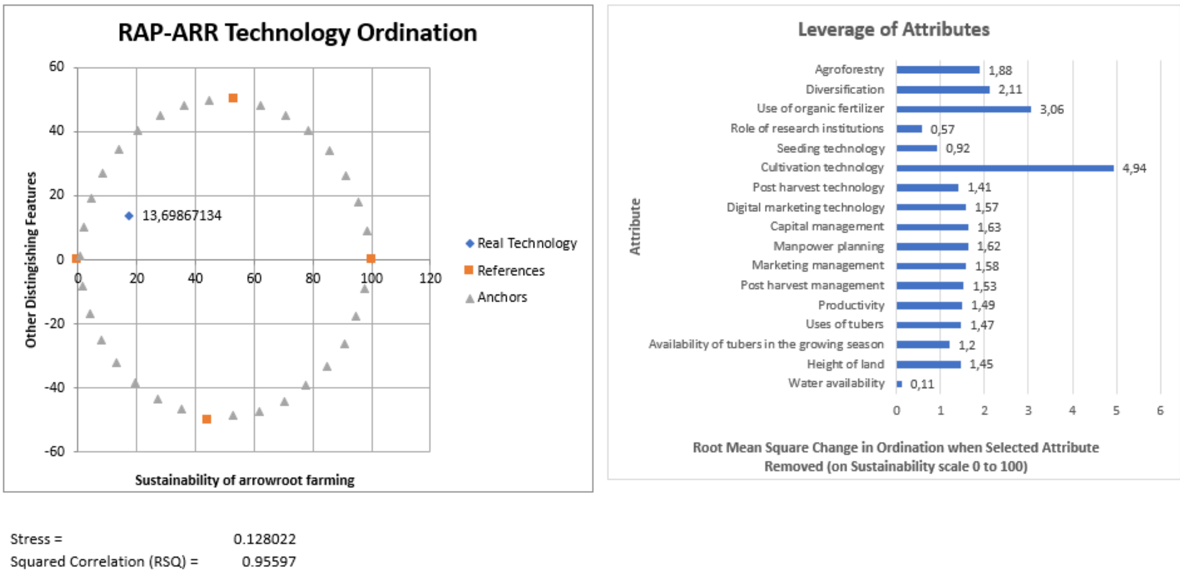


Figure 4: Sustainability in terms of social dimension

ajfand Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

In contrast to the other three dimensions, in the technology dimension, as presented in Figure 5, the results of the ordination of the sustainability of arrowroot plant development have an index of 13.70, which means it has an unsustainable status. Meanwhile, the R^2 value is 95.5%, with a stress value of 0.13. This result indicates that 95.5% of the data variation can be explained by the factors included in the model. Thus, judging from the R^2 value and the stress value, the results of this technology dimension MDS show a good model to capture technological problems, so that the technology dimension analysis does not require additional attributes.



(a) (b)

Figure 5: Sustainability in terms of the Technology dimension

Furthermore, with the three dimensions whose sustainability status is less sustainable and the technology dimension whose status is not sustainable, the overall sustainability status becomes less sustainable, with a sustainability index of 36.15 (see Table 3).

From the results of the difference between the sustainability index values and the Monte Carlo values presented in Table 3, the environmental, economic, and social dimensions have a less sustainable status because the difference between the two sustainability index values is less than 1. Meanwhile, the technology dimension is concluded to be unsustainable because the difference is more than 1.

Sensitivity analysis

According to the results, the development of arrowroot plants in Kulon Progo Regency is less sustainable. Thus, efforts to improve the sustainability status are needed to raise the sustainability status of each dimension from unsustainable to sustainable. Improvement efforts can be made by increasing the value/index of each dimension's attribute that has great potential as a strategic approach to guide development toward greater sustainability [18,24,25].

In the environment dimension (Figure 2b. leverage), if three priorities are taken, the first one is the attribute of the impact of pests and diseases (average value 11.35), the second is water conservation (8.49), and the third is land conditions (8.45). The main pests that attack arrowroot plants are Scarabaeidae larvae, rats and leaf-rolling caterpillars (*Colopodes atheus*). Meanwhile, the primary diseases that attack arrowroot plants are leaf burn (*Rosellinia atheus*) and leaf rot (*Pelliularian filomentosa*) [27]. Pest and disease attacks have a significant effect on reducing production yields. Therefore, managing the possibility of pest and disease attacks needs to be done as much as possible, especially by taking precautions to protect arrowroot plants from pests and diseases and simultaneously reduce the cost of handling them.

Similarly, water conservation management is vital as arrowroot plants require moist soil. Arrowroot plants live in moist moorlands and forests [28–30]. Furthermore, attributes of land conditions are also linked to water conservation. If water conservation management is good, the expectation that land conditions are well managed is higher. In addition, arrowroot plants can grow well under shade. For this reason, arrowroot land can be optimally utilized by planting soft-rooted shade plants such as papaya and banana or perennials such as rubber, rambutan and teak trees [27].

In the economic dimension, as listed in Figure 3 (3b. leverage), the two attributes that contribute most are farming experience and the role of the government in exports, respectively. The experience attribute plays a significant role because, with much experience, farmers have learned through direct practice, so they understand the ins and outs of arrowroot farming practices, which will have an impact on increasing production or at least being able to maintain existing achievements. Although the average education of farmers is still low, farmers with long experience can produce high production levels [31,32]. Further, another attribute that could be improved is the role of the government in exporting. This is closely related to the potential of arrowroot as a substitute for wheat flour and functional food [12], which makes it of high economic value and an export opportunity. However, until this study was conducted, the government's role in facilitating exports from arrowroot tuber processors had not been done much. Therefore, the government's facilitation role for processed arrowroot products is highly expected.

In the social dimension, based on the results of the leverage analysis listed in Figure 4 (b), it can be seen that three attributes contribute significantly. The first is development policy, the second is marketing institutions, and the third is farmers' response to technology. The development policy attribute plays the most significant role because the development policy can determine whether a commodity can develop well. Even so, the reality in the field shows that differences in development results also depend on the role of the farmer group [33]. In the arrowroot farmer group in Kulon Progo Regency, the group leader motivates farmers to process their arrowroot crops into starch and package them so that they look marketable and attract potential consumers. This result is related to the second attribute that contributes significantly, namely marketing institutions. The Arrowroot farmers market their products through farmer groups to reach a broader market. These findings are consistent with Diyahya *et al.* [34] that the role of marketing institutions is vital for farmer satisfaction level in marketing their farm products. In addition, farmers' response to technology is the third attribute that contributes to the social dimension. At the time of the research, conditions in the field showed that arrowroot farming cultivation technology was still very simple. Even though arrowroot farming in Kulon Progo has contributed much to their household income, farmers still depend more on the growth and maintenance of farms in a makeshift manner [10]. Therefore, if farmers' response to technology can be improved, the contribution of arrowroot farming to their welfare will also increase.

Furthermore, in the technology dimension, based on the results of the leverage analysis listed in Figure 5 (b), only two attributes contribute significantly. The first attribute is cultivation technology, and the second is organic fertilizer. It has been argued that, based on conditions in the field, arrowroot cultivation technology is still very simple or inadequate. For example, soil fertilization is often not done; if it is done, it is only limited to utilizing the remaining fertilizer from other plants. Soil fertilization practices for each crop must be improved because technology plays an important role in increasing the success of farming efforts [35]. In line with these conditions, another attribute that can be improved is organic fertilizer. Improving the use of organic fertilizer can be pursued by utilizing the potential objects around the farmer's environment. Farmers can make organic fertilizer independently from their livestock or compost from the waste of cultivated plants. This needs to be done because organic fertilizer plays a role in improving the soil's physical, chemical and biological fertility, as well as making the use of inorganic fertilizer more efficient [36,37,38]. By increasing the use of organic fertilizers in arrowroot cultivation, production is expected to increase while supporting environmental sustainability and increasing farmers' income and welfare.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The analysis of arrowroot development in Kulon Progo Regency of Indonesia, as a raw material for a sustainability-based food processing industry, assessed through four sustainability dimensions, namely environmental, economic, social and technological dimensions, indicates that its current status is less sustainable.

Improving sustainability requires strategic interventions across all dimensions. In the environmental dimension, improvements are needed to reduce the impacts of pests and diseases through better management practices, as well as to enhance water conservation and land conditions by applying shading crops. In the economic dimension, improvements should focus on strengthening farming experience through mentoring by more experienced farmers and enhancing the government's role in export development, including export market exploration through agricultural exporter networks and improvements in product quality and production continuity. In the social dimension, improvement strategies should address development policies and marketing institutions by formulating a clear development roadmap in collaboration with universities and relevant institutions. Meanwhile, in the technological dimension, improvements are required in cultivation technology and the use of organic fertilizers, which can be achieved through training on tuber crop cultivation technologies and the production and application of organic fertilizers based on local resource potential.

ACKNOWLEDGEMENTS

This work was supported by the LPPM Universitas Sebelas Maret (Grant numbers: 228/UN27.22/PT.01.03/2023 and 194.2/UN27.22/PT.01.03/2024).

DECLARATION OF COMPETING INTERESTS

There are no financial or personal conflicts of interest between the authors and any individuals or organizations that could inappropriately influence this work.

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 26 No. 3
March 2026
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Dimensions and indicators/attributes of the sustainability dimension

Dimension	Attribute
Environment	Land conservation, Water conservation, Land condition, Pest and disease impact, Pest and disease frequency Climate condition
Economy	Farming cost, Income, Harvest price, Role of government for export, Role of processing industry, Farming experience, Farmer's age, Availability of capital, Availability of labour, Land tenure
Social	Good Agricultural Practises, Farmer response to technology, Development policies, Marketing institutions, Farmer groups, Access to capital, Land conversion, District-level associations
Technology	Water availability, Land elevation, Availability of tubers in the growing season, Use of tubers, Productivities, Post-harvest management, Marketing management, Labour planning, Capital management, Digital marketing technology, Post-harvest technology, Cultivation technology, Seeding technology, Role of research institutions, Use of organic fertilizer; Diversification, Agroforestry

Source: Modified from [18, 24, 25, 37] based on the results of focus group discussions with key persons

Table 2: Sustainability status index

Score	Index Status
0 – 25	Unsustainable
<25 - < 50	Less sustainable
<50 - < 75	Moderately sustainable
<75 - < 100	Sustainable

Source: [18, 24, 25]

Table 3: Sustainability status

Dimension	Index (ordination)	Sustainability Status	Monte Carlo	Difference between index and Monte Carlo
Environment	36.14	Less sustainable	36.57	0.43
Economy	42.98	Less sustainable	42.88	0.10
Social	48.27	Less sustainable	48.17	0.10
Technology	13.70	Not sustainable	20.07	6.37

REFERENCES

1. **Angon PB, Khan MMR and SH Tonny** An Assessment of the Interaction between Carbon Dioxide Emissions and Available Nutrients from the Lifecycle of Several Agricultural Crops. Caraka Tani: *Journal of Sustainable Agriculture.* 2022; **37(2)**: 373–384. https://jurnal.uns.ac.id/carakatani/article/view/61029

2. **Delincé J, Ciaian P and HP Witzke** Economic impacts of climate change on agriculture: the AgMIP approach. 2015; **9(1)**:097099. https://www.spiedigitallibrary.org/journals/journal-of-applied-remote-sensing/volume-9/issue-1/097099/Economic-impacts-of-climate-change-on-agriculture--the-AgMIP/10.1117/1.JRS.9.097099.full

3. **Bandara JS and Y Cai** The impact of climate change on food crop productivity, food prices and food security in South Asia. *Econ Anal Policy*. 2014; **44(4)**: 451–465. https://www.sciencedirect.com/science/article/pii/S0313592614000502

4. **Muthukumaran S, Geetha P and E Ramaraj** Multi-Objective Optimization with Artificial Neural Network Based Robust Paddy Yield Prediction Model. Intelligent Automation and Soft Computing. 2022; **35(1)**: 215–230. https://www.techscience.com/iasc/v35n1/48160/html *Accessed June 2025*.

5. **Antriyandarti E, Agustono, Rusdiyana E and SW Ani** Does Indonesia Need to Import Rice? *International Journal of Sustainable Development and Planning.* 2024; **19(10)**: 4093–9. https://www.doi.org/10.18280/ijsdp.191037

6. **Pratama IA, Suryantini A and H Perwitasari** Sustainability of the Different Rice Cultivation Practices in Yogyakarta, Indonesia. Caraka Tani: *Journal of Sustainable Agriculture*. 2024; **39(2)**: 321–42. https://jurnal.uns.ac.id/carakatani/article/view/85817

7. **Total Rice Production.** March-April 2024 Estimated to be 8.46 Million Tons - Kompas.id. https://www.kompas.id/baca/english/2024/03/01/en-total-produksi-beras-maret-april-2024-diperkirakan-846-juta-ton *Accessed June 2025.*

8. **Wariyah C, Huda N and A Slamet** The Prebiotic Index of Dried-Growol Made with Different Cassava Varieties and Cooking Methods. Caraka Tani: *Journal of Sustainable Agriculture.* 2025; **40(1)**: 97–108. https://jurnal.uns.ac.id/carakatani/article/view/84506

9. **Fajrin M, Mahdi I and AHA Putri** Arrowroot Tuber as a Commodity in the Food Diversification Program Based on Local Wisdom in the Era of COVID-19. BIO Web Conf. 2024; **144**: 05002. https://www.doi.org/10.1051/bioconf/202414405002

10. **Sundari MT, Rahayu ES, Irianto H, Handayani SM, Setyowati and F Widadie** Cost and revenew analysis of arrowroot farming in Yogyakarta, Indonesia. *IOP Conf Ser Earth Environ Sci.* 2024; **1362(1)**: 012018. https://iopscience.iop.org/article/10.1088/1755-1315/1362/1/012018 *Accessed June 2025.*

11. **Octavia D, Wijayanto N, Budi SW, Batubara I and S Suharti** Total Phenolic and Starch Content of Arrowroot Tuber in The Agroforestry System. *Forest Sci Technol.* 2024; **20(1)**: 78–90. https://www.tandfonline.com/doi/pdf/10.1080/21580103.2023.2298480 *Accessed June 2025.*

12. **Dewi MT and N Rustanti** Pengaruh Penambahan Telur Terhadap Kandungan Zat Gizi, Volume Pengembangan Dan Uji Kesukaan Blondies Garut (Marantha arundinacea) Sebagai Alternatif Makanan Bagi Sindrom Autisme. *Journal of Nutrition College*. 2012; **1(1)**: 160–8. https://ejournal3.undip.ac.id/index.php/jnc/article/view/731

13. **Deswina P and D Priadi** Development of Arrowroot (*Maranta arundinacea* L.) as Functional Food Based of Local Resource. *IOP Conf Ser Earth Environ Sci.* 2020; **439(1)**: 012041. https://iopscience.iop.org/article/10.1088/1755-1315/439/1/012041

14. **Fidianingsih I, Aryandono T, Widyarini S, Herwiyanti S and S Sunarti** Arrowroot (*Maranta arundinacea* L.) as a new potential functional food: A scoping review. *Int Food Res J*. 2022; **29(6)**: 1240–1255.

15. **Hora SC** Probability Judgments for Continuous Quantities: Linear Combinations and Calibration. 2004; **50(5)**: 597–604. https://www.jstor.org/stable/30046100 *Accessed June 2025.*

16. **Lingkungan JT, Handika R, Widodo J and AE Pravitasari** Combined Land Subsidence Analysis in Jakarta Based on Ps-InSAR and MICMAC Methods. Jurnal Teknologi Lingkungan. 2024; **25(1)**: 137–45. https://ejournal.brin.go.id/JTL/article/view/1125

17. **Sukwika T** Menentukan Populasi Dan Sampling. Metode Penelitian "Dasar Praktik Dan Penerapan Berbasis ICT," 2023.

18. **Irianto H, Mujiyo M, Qonita A, Sulistyo A and EW Riptanti** The development of *jarak towo* cassava as a high economical raw material in sustainability-based food processing industry. *AIMS Agriculture and Food* 2021; **6(1)**: 125–41. https://doi.org/10.3934/agrfood.2021008

19. **Pitcher TJ, Bundy A, Preikshot D, Hutton T and D Pauly** Measuring the unmeasurable: a multivariate and interdisciplinary method for rapid appraisal of the health of fisheries. In: Reinventing fisheries management. Springer; 1998. p. 31–54.

20. **Pitcher TJ and D Preikshot** RAPFISH: a rapid appraisal technique to evaluate the sustainability status of fisheries. *Fish Res.* 2001; **49(3)**: 255–70.

21. **Fauzi** Pemodelan sumber daya perikanan. Gramedia Pustaka Utama; 2005.

22. **Widadie F, Rahayu, ES, Irianto H, Handayani SM, Setyowati and MT Sundari** Farmers' perception of the integrated farming system of arrowroot and livestock in supporting a zero-waste agriculture system. BIO Web of Conferences. 2025; **155**: 125–06006. https://doi.org/10.1051/bioconf/202515506006

23. **Riptanti EW, Irianto H and Mujiyo** Strategy to improve the sustainability of "porang" (*Amorphophallus muelleri* Blume) farming in support of the triple export movement policy in Indonesia. *Open Agric.* 2022; **7(1)**: 566–80. https://doi.org/10.1515/opag-2022-0121

24. **Durroh B, Darsono, Irianto H and EW Riptanti** Integrated Model for the Sustainable Development of the Arabica Java Ijen Raung Specialty Coffee Agroindustry: A Two-Stage Approach. *Int J Sustain Dev Plan*. 2025; **20(12)**: 5271–5288. https://doi.org/10.18280/ijsdp.201220

25. **Hadi K, Santoso PB, Maulidah S and A Wahib Muhaimin** Sustainable Business Models: Challenges on potato agro-industry SMEs. *IOP Conf Ser Earth Environ Sci.* 2021; **709(1)**: 012082. https://iopscience.iop.org/article/10.1088/1755-1315/709/1/012082

26. **Maulidah S and A Wahib Muhaimin** Sustainable Business Models: Challenges on potato agro-industry SMEs. *IOP Conf Ser Earth Environ Sci.* 2021; **709(1)**: 012082. https://iopscience.iop.org/article/10.1088/1755-1315/709/1/012082

27. **Sukarsa E** Tanaman Umbi Garut — BBPP Lembang. 2011. https://bbpplembang.bppsdmp.pertanian.go.id/publikasi-detail/1138 *Accessed June 2025.*

28. **Leamkheng S, Santibenchakul S, Poonpaerdchon S, Soem B and N Sooksawat** Growth performance and starch yield potential of arrowroot (Maranta arundinacea) from various locations in Thailand. *Biodiversitas.* 2024; **25(10)**: 3750–7. https://doi.org/10.13057/biodiv/d251037

29. **Oktafani MB, Supriyono, Budiastuti MS and D Purnomo** Performance of Arrowroot (*Marantha arundinacea*) in various light intensities. *IOP Conf Ser Earth Environ Sci.* 2018; **142(1)**: 012048. https://doi.org/10.1088/1755-1315/142/1/012048

30. **Qodliyati M, Supriyono and S Nyoto** Influence of spacing and depth of planting to growth and yield of arrowroot (*Marantha arundinacea*). *IOP Conf Ser Earth Environ Sci.* 2018; **142(1)**: 012035. https://doi.org/10.1088/1755-1315/142/1/012035

31. **Ngurah G, Sugiantara M and MS Utama** Pengaruh Tenaga Kerja, Teknologi Dan Pengalaman Bertani Terhadap Produktivitas Petani Dengan Pelatihan Sebagai Variabel Moderating. *Buletin Studi Ekonomi.* 2019; **24(1)**: 1–17. https://ojs.unud.ac.id/index.php/bse/article/view/51446

32. **Tunas OO, Ngangi CR and JFJ Timban** Pengaruh Luas Lahan Dan Pengalaman Berusahatani Terhadap Pendapatan Petani Padi Di Desa Taraitak I Kecamatan Langowan Utara Kabupaten Minahasa. *AGRI-SOSIOEKONOMI.* 2023; **19(1)**: 441–8. https://ejournal.unsrat.ac.id/v3/index.php/jisep/article/view/46439

33. **Amarullah A, Adiwena M and F Arifin** Teknologi Budidaya dan Produksi Tanaman. Banca Aceh: Syiah Kuala University Press; 2023. Available from: https://www.google.com/books?hl=id&lr=&id=3n8HEQAAQBAJ&oi=fnd&pg=PP1&dq=Teknologi+Budidaya+dan+Produksi+Tanaman.+Syiah+Kuala+University+Press&ots=NTp05hcv8f&sig=mDEGztleYT-87te3dUJ2DHHgi8E *Accessed May 2025.*

34. **Diyahya I, Sukiyono K, Redy Badrudin D, Dan A, Pengajar S and J Sosial** Analisis Tingkat Kepuasan Petani Jagung Terhadap Pelayanan Lembaga Pemasarannya Di Kecamatan Lubuk Pinang Kabupaten Mukomuko. *Jurnal AGRISEP: Kajian Masalah Sosial Ekonomi Pertanian dan Agribisnis*. 2016; **15(1)**: 45–58. https://ejournal.unib.ac.id/agrisep/article/view/845

35. **Purnomo MME** PPT Presentation Kementerian Pertanian. 2022. KEBIJAKAN DAN PERAN KEMENTERIAN PERTANIAN DALAM PEMBERDAYAAN PETANI. https://pusdik.mkri.id/materi/materi_279_PAPARAN%20NARSUM%20DI%20PUSDIK%20MK-01.pdf *Accessed June 2025.*

36. **Hartatik W, Husnain H and LR Widowati** Peranan Pupuk Organik dalam Peningkatan Produktivitas Tanah dan Tanaman. *Jurnal Sumberdaya Lahan.* 2015; **9(2)**: 107–20. https://repository.pertanian.go.id/items/6fb70906-8529-48f5-be7e-2078890ff9a9 *Accessed May 2025.*

37. **Firmansyah I, Widiatmaka W, Pramudya B and S Budiharsono** Sustainability status of rice fields in the rice production center of Citarum Watershed. *AACL Bioflux*. 2016; **8(1)**: 13–25. https://aab.bioflux.com.ro/docs/2016.13-25.pdf *Accessed May 2025.*

38. **Kinanti R, Yustiana Y and R Esyanti** Integrating Business Model Canvas and Balanced Scorecard for Porang Tuber Business Development: A Case Study of Koperasi Porang Garut Agro. Caraka Tani: *Journal of Sustainable Agriculture.* 2026; **41(1)**:46–65. https://doi.org/10.20961/carakatani.v41i1.106736