A SUSTAINABLE PORANG (*AMORPHOPHALLUS MUELLERI* BLUME*)* FARMING MODEL TO SUPPORT EXPORT INCREASE: EMPIRICAL STUDY IN WONOGIRI REGENCY, INDONESIA

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Abstract. Porang (*Amorphophallus muelleri* Blume*)* is a potential food crop developed in Wonogiri Regency and has spread to several parts of Indonesia. Porang corms have high economic value and export demand. Porang farming is multi-year and requires larger capital to develop than other staple food crops. This study aimed to examine a sustainable farming model to support the export increase and applied a survey method by taking 180 porang farmers in six sub-districts in Wonogiri Regency, Central Java, Indonesia. The porang farming sustainability model was built with one endogenous variable (sustainability of porang farming), five exogenous variables (environmental, family resource, institutions, technology, and farm management), and one intermediate variable (farming output). Data analysis used a Simultaneous Equation Model (SEM) with WarpPLS 6.0 software. The results showed that the porang farming model was sustainable if supported by family resources, institutions, and good farming management. Porang farming requires large capital, and therefore status, land tenure, and family labor are the main keys to the success of its cultivation. Meanwhile, porang farmer associations, farmer partners, and the government are expected to build and develope porang farmer institutions. Farmers, as managers, must be able to manage their inputs and resources to achieve optimal productivity.
Keywords: *family resources, institutional, productivity, farm management, technology*

Introduction

Porang or commonly called iles-iles *(Amorphophallus muelleri* Blume) is one of the corms varieties in Indonesia. This plant is a tropical or sub-tropical plant that has not been widely cultivated by farmers and is a wild plant (Sari and Suhartati, 2015). The porang plant was originally found in India's Andaman Islands and then spread eastward through Myanmar, Thailand, and Indonesian territory (Sumarwoto, 2005). This plant was quite famous in the 1960s before finally being abandoned, that is this plant has not been cultivated intensively. Porang corms are multi-year plants that produce carbohydrates. Porang grows wild on the edge of teak forests, under bamboo clumps, on riverbanks, in thickets, and under shade up to 50-75% (Santosa et al., 2006; Afifah et al., 2014; Tajuddin et al., 2020). The suitable temperature is between 25-35 ^{o}C, with rainfall between 1,000-1,500 mm during the growing period. If the temperature is above 35 ^{o}C, the plant leaves will burn, while at low temperatures, the porang plant will become dormant (Siswanto and Karamina, 2016).

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Porang corms have high economic value because they contain glucomannan which is good for health (Chua et al., 2010; Mekkerdchoo et al., 2016). Starting in 2009, an alternative source of glucomannan in Indonesia was produced from porang corms (Hermanto et al., 2019). High glucomannan content was obtained from the purification of porang flour by maceration method (Faridah, 2016; Yanuriati et al., 2017). Standardization of the purity of porang flour has been widely applied to various types of food to improve physical properties, such as sausages and processed meats (Widjanarko et al., 2018). In addition, glucomannan is used by the textile and paper industries as adhesives, celluloid materials, and cosmetics (Zhang et al., 2010).

The benefits of porang corms glucomannan cause increasing demand for this commodity as an industrial raw material (Hermanto et al., 2019), as reflected in *Fig. 1*. The Agricultural Data and Information System Center informed that in 2020 there was a significant increase in porang exports compared to 2019. This makes porang one of the priority export commodities included in the triple export movement (GRATIEKS) program by the Ministry of Agriculture. However, in 2021, there was a decline in exports due to the application of porang certification to be exported by importing countries. Nevertheless, promising export opportunities encourage the expansion of porang cultivation in Indonesia.

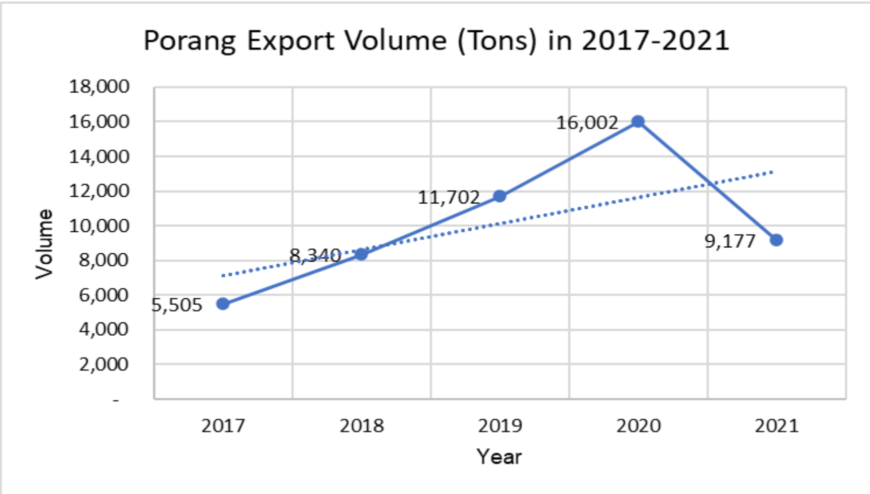

Figure 1. *Porang Export Volume (Tons) in 2017 – 2021, source: Agricultural Data Center and Information System (2022)*

Porang is exported to China, Japan, Vietnam, Thailand, Hong Kong, Malaysia, South Korea, New Zealand, Italy, and Pakistan (Sutrisno, 2021). The demand for porang continues to increase in fresh and dry chips. Porang is exported to these countries in flour and other preparations to add higher value (Mekkerdchoo et al., 2016).

Regions in Indonesia that produce porang include the islands of Java, Sulawesi, Nusa Tenggara, and Bali. The main porang producing regions in Indonesia are East Java and Central Java (Ministry of Agriculture, 1994). In the Central Java region, the centres of porang production are generally in Cepu and Blora Regencies (Rahayuningsih, 2020). Several districts have started cultivating porang, one of which is in Wonogiri District. The development of porang cultivation is experiencing financial constraints in the form of low capital, innovation, and creativity in porang plants. According to Al-Hamdhan

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(2021), the costs incurred on porang farming in Madiun per hectare per year reach more than IDR 86,000,000, which is greater than that of other food commodities. Most of the costs are used to purchase porang seedlings (Susanawati et al., 2021). High selling prices follow high farming costs. However, there are some conditions where the selling price drops drastically due to market constraints (Al-Hamdhan, 2021). Market factors that tend to be monopsony are also a consideration in sustainable cultivation (Riptanti et al., 2022). According to Arafia et al. (2020), this happened due to the lack of information on the porang marketing system and the weak bargaining position with partners. The sustainability of farming needs the support of marketing and capital institutions. Even though the selling price of porang is high, the risks and high operational costs reduce the net profit. Finally, the question will arise whether porang farming can continue. This study aimed to determine the sustainable porang farming model in Wonogiri Regency in supporting porang exports in Indonesia.

Materials and Methods

Theoretical Study and Hypothesis Development

The effects of environmental inputs on farm output. Farming as an effort to be sustainable is influenced by environmental inputs (Othman and Hasan, 2016). Good quality of environmental inputs will increase the profits of the concerned farm (Clark and Tilman, 2017). Based on the results of this study, the first hypothesis (H1) was proposed:

H1: Environmental inputs positively affected the output of porang farming.

The effects of family resource input on farm output. Farmers in farming often involve their family resources. Family involvement in farming is common so that more family members will reduce the need for workers outside the family (Pinem et al., 2022; Hamilton et al., 2022). Based on the results of the study, the second hypothesis (H2) was formulated:

H2: The input of family resources positively affected the output of porang farming.

The effects of cropping patterns on farm output. The cropping pattern applied by farmers in farming will vary depending on the condition of the land, as well as the socio-economic status of the farmer. Differences in cropping patterns will impact crop yields (Kamkar, 2016; Jones et al., 2021). Hypothesis 3 (H3) was structured as follows:

H3: Cropping pattern positively affected the output of porang farming.

The effects of institutional on farm output. The success of farming cannot be separated from the role of institutions in the form of social and economic institutions. If this role is not optimal, the development of agribusiness commodities will also be hampered (Muro and Tridico, 2008; Paendong et al., 2020). The fourth hypothesis (H4) was structured as follows:

H4: Institutions positively affected the output of porang farming.

The effects of technology on farm output. The use of technology plays a major role in farming, especially in technical efficiency (Venkatesh, 2016; Farhangi et al., 2021). Hypothesis 5 (H5) was structured as follows:

H5: Technology affected the output of porang farming.

The effects of farm management on farm output. Farmers in farming act as owners and managers. As a manager, his role will determine the success of the business he manages, because as a farmer manager he will try to achieve higher productivity and maximum profit (Li et al., 2017). The 6th hypothesis (H6) was structured as follows:

H6: Farm management affected the output of porang farming.

The effects of farm output on the sustainability of farming. Increasing farm output will ensure the sustainability of farming. This is because increasing yields will motivate farmers to improve their farm management (Cotîrlea, 2011). The 7th hypothesis (H7) is structured as follows:

H7: Output positively affected the sustainability of porang farming.

Hypothesis testing H1 to H7 is shown in *Figure 2*.

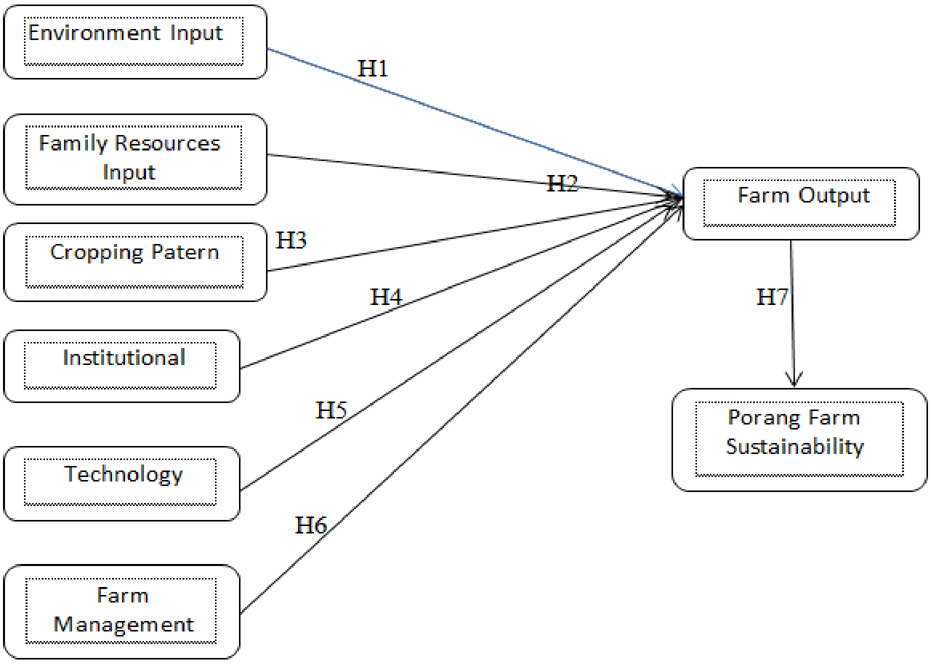

***Figure 2.** A Sustainable Porang Farming Model*

Operational Definition and Measurement

The porang farming model built included exogenous and endogenous latent variables. Exogenous latent variables are variables that affect and are not influenced by the system, while endogenous latent variables are variables that affect and are influenced by other variables (Almeida et al., 2013). Exogenous latent variables consisted of environmental inputs (X1), family resource inputs (X2), cropping patterns (X3), institutional (X4), technology (X5), and farm management (X6). Endogenous latent variables consisted of output (O) and sustainability of porang farming (Y), as shown in *Table 1*.

Research Location and Sampling Procedure

This study used a descriptive causal method where the research location was from 6 sub-districts in Wonogiri Regency, namely Jatisrono, Jatipurno, Jatiroto, Slogohimo, Karangtengah, and Girimarto (*Fig. 3*). From each sub-district, 30 samples of porang farmers were taken, so the number of samples used in this study was 180 respondents. Respondents were taken using snowball sampling (Naderifar et al., 2017). This is due to the inadequacy of official data published by the Wonogiri Regency Agriculture Service.

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Table 1. *Operational Definitions and Indicators of Research Variables*

Latent Variable	Operational Definition	Indicator
Environment input (X1)	Farming environment inputs are everything around the farm and affect the development of farming life (Repar et al., 2017). The environment greatly influences the sustainability of the agricultural system (Hasan and Kumar, 2022).	a. Climate suitability (Repar et al., 2017; Hasan and Kumar, 2022; Indriyani et al., 2011; Kogo et al., 2022; Zhang et al., 2022; Pineda et al, 2020; Zhao et al., 2022). b. Frequency of pest and disease attacks (Palayukan et al., 2021; Allen et al., 2018). c. Impact of pest and disease attacks (Soedarjo et al., 2021). d. Land conditions (Effendi et al., 2020; Semin and Namyatova, 2019). e. Water conservation (Qin et al., 2020; Momenpour et al., 2021). f. Land conservation (Sui et al., 2022).
Input family resources (X2)	Family resource inputs are family members participating in farming activities (Wilson and Tonner, 2020) in physical and non-physical forms (Hassan, 2021).	a. Land tenure (Riptanti et al., 2021). b. Labor availability (Pinem et al., 2022; Hamilton et al., 2022). c. Availability of farming capital (Riptanti et al., 2022) . d. Age of farmers (Seok et al., 2018). e. Porang farming experience (Wilson and Toner, 2019; Ainembabazi and Mugisha, 2014).
Cropping pattern (X3)	Cropping pattern is the proportion of a plot of land planted by various types of crops at a certain time (Aduvukha et al., 2021). A good cropping pattern must be adapted to farmers' ability regarding the availability of their facilities, land area, land conditions, and the local environment's social and cultural conditions (Kamkar, 2016).	a. Agroforestry system (Elsoilah, 2021; Sari and Suhartati, 2015; Desmiwati et al., 2021). b. Diversified farming system (Jones et al., 2021; Riptanti et al., 2021; Prasad and Tazeen, 2021). c. Organic farming system (Kowalska et al., 2017; Muneret et al., 2019; Mufidah et al., 2021).
Institutional (X4)	Institutions are systems, arrangements, and patterns (Farkas, 2019) that form relationships or interactions between humans in order to provide order to achieve common goals (Muro and Tridico, 2008).	a. The role of establishing the porang community (Riptanti et al., 2022; Van Vu et al., 2020). b. The role of the porang processing industry (Rahmi et al., 2021; El-Enbaby et al., 2016). c. The role of research institutions in technology transfer (Ojijo, 2016; Douthwaite et al., 2017; Mgendi et al., 2019). d. The role of the government in export facilitation (Riptanti et al., 2022; Priyanto, 2017).
Technology (X5)	Technology is everything humans create from thoughts, ideas, and knowledge to achieve a certain goal (Carroll, 2017). Technology in agriculture aims to reduce costs and improve the quality and quantity of agricultural products (Venkatesh, 2016)	a. Seed technology (Sari et al., 2019; Fauzan et al., 2022; Soedarjo, 2021). b. Cultivation technology (Harijati and Ying, 2021; Riptanti et al., 2022). c.Post-harvest technology (Uchechukwu-Agua et al., 2015). d. Digital marketing technology (Boedirachminarni et al., 2017).

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Latent Variable	Operational Definition	Indicator
Farming Management (X6)	Farm management is a process of making and implementing decisions (Cros et al., 2003) at the farm level by organizing activities to achieve higher productivity and maximum profit (Q.Li et al., 2017).	a. Capital management (Holt and Morris, 2022). b. Labor management (Chmieliński et al., 2022; Ragkos et al., 2018). c. Marketing management (Crawford, 1997; Iqbal et al., 2020). d. Post-harvest management (Nurlela et al., 2022; Soemantri et al., 2021).
Output (O)	Output is all the results of cultivated agricultural businesses (Suh and Moss, 2021) in one unit area (Cros et al., 2003).	a. Porang tuber production (Aini et al., 2020; Khoiri et al., 2022). b. Production of bulbil (Dermoredjo et al., 2021; Asih et al., 2018). c. Farmers' income (Dermoredjo et al., 2021; Riptanti et al., 2022).
Farming sustainability (Y)	Sustainability of farming is a method and process to increase the productivity of agricultural products by minimizing the use of non-renewable inputs so that agricultural resources and the output produced as food can be felt by future generations (Firbank, 2018). Farming is said to be sustainable if it can balance environmental sustainability and economic benefits and can be accepted by the social order of the local community (Pietrzak and Drangert, 2018)	a. Use of frog tubers (Bulbil) at planting (Khoiri et al., 2022; Riptanti et al., 2022). b. Availability of bulbil during the growing season (Ferziana et al., 2021; Harijati and Ying, 2021). c. Land elevation (Yasin, 2021; Filho et al., 2022). d. Availability of water at the beginning of the growing period (Silva et al., 2018; Riptanti et al., 2022). e. Land conversion (Hindersah et al., 2018; Arunrat et al., 2022). f. Porang tuber productivity (Supriyono et al., 2021; Riptanti et al., 2022). g. Cost of porang farming (Riptanti et al., 2022).

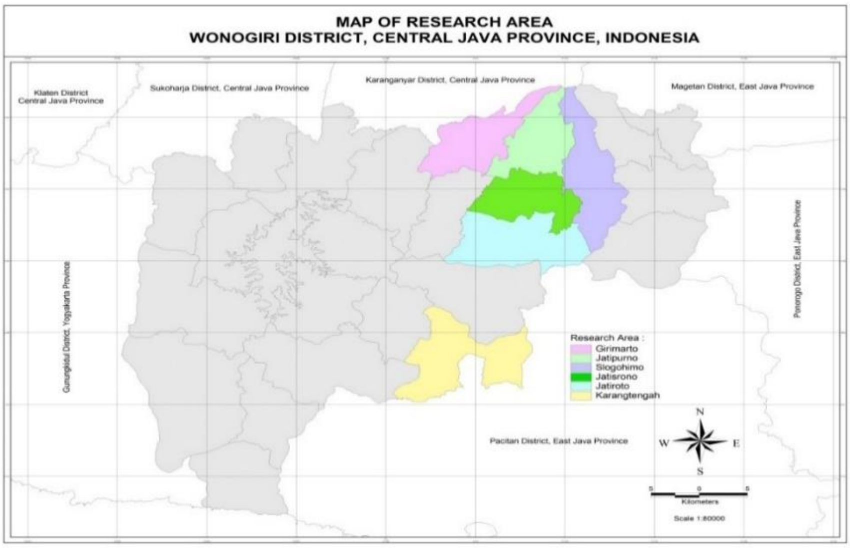

__Figure 3.__ Research location

Data Analysis

Data were analyzed using WarpPLS 6.0 software with the Simultaneous Equation Model (SEM) method to formulate the relationship pattern and sustainability model of porang farming in Wonogiri in supporting exports. Testing of the model goes through two stages: the first stage of testing the research instrument by testing the validity and reliability, and the second stage by evaluating the outer and inner models (Rifa'i, 2015).

Validity Test

Testing the instrument's validity was seen through the loading factor value and the Average Variance Extracted (AVE) value. The loading factor on the indicator must be > 0.7, and the AVE must be > 0.5 in confirmatory research (Rifa'i, 2015). The results of the instrument validity test showed that nine indicators were not valid because the value was <0.7, so they were eliminated for further research (Firbank, 2018) (*Appendix 1*). The AVE values of the eight latent variables studied were all declared valid (Rifa'i, 2015) (*Appendix 2*).

Reliability Test

Testing the instrument's reliability using the Composite Reliability (CR) and Cronbach's Alpha (CA) approaches. CR values higher than 0.6 and CA higher than 0.70 a variable is considered reliable (Rifa'i, 2015). The reliability test results showed that the CR value of all the variables studied was > 0.6, and the CA value was > 0.7 (*Appendix 3*), so all the variables studied are reliable.

Results and Discussion

Characteristics of Porang Farmers

Characteristics of farmers play an important role in porang farming. Regarding gender, 94.44% of porang farmers were male, while only 5.54% were female. Generally, men dominate farming, while women are more domestic and help the head of the family. Formal education in junior and senior high schools had a proportion of 48.89%, but those who were not educated until the elementary school graduate category was still high at 47.22%. Highly educated farmers were only 3.89%. A larger proportion of farmers with high school and tertiary education allows farmers to be more open to innovation (Van Vu et al., 2019), which is indeed needed to change a different perspective from rice, corn, and cassava farming to switch to porang farming.

Age categorization according to Widiyanti et al. (2020) is divided into 2 classes, namely young farmers if they are 25-34 years old and old farmers if they are ≥35 years old. The age of farmers showed that most of the farmers were old farmers aged >35 years (Riptanti et al., 2022), which was 92.78%, while those young farmers aged 25 – 34 years was 7.22%. This shows that education has more influence on the choice of commodity types than the effect of age on the choice of selected farming commodities (Abdullah et al., 2019).

In terms of occupation, although the largest proportion was farmers (48.89%), the proportions of entrepreneurs and village officials were quite large, 30.56% and 12.22%, respectively. This is understandable because porang farming requires large funds compared to seasonal crop farming, and the harvest is only once a year (Riptanti and Irianto, 2022). Porang farmers who work as entrepreneurs and village officials have

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more capital and are considered agents of reform (Ogbanje et., 2015). The results showed that the proportion of super small farmers (< 0.25 Ha) was only 27.22%, while the proportion of small farmers (0.25 - < 0.50 Ha) was 40.56%, medium farmers (0.50 - ≤ 1.0 Ha) were 13.33% and large farmers (> 1.0 Ha) by 18.89%. This shows that 68% of the farms were less than 0.5 hectares, that small-scale farming dominates the porang production in the study area. The greater proportion of farmers who land more than 0.25 Ha, the more assumption that porang business requires large capital and the results are also large (Al-Hamdhan, 2021).

The source of funding for porang farming showed that the proportion of financing from own capital sources was the largest (86.67%), joint capital (own capital and investors) was 7.78%, and finally, own capital and loans were 5.55% (Vuckovic et al., 2017). This condition indicates that farmers were quite careful in porang farming. The profit opportunity is large, but the risk is also great, so farmers avoid taking the risk of doing business with loan capital (Herliana et al., 2018).

Sustainability Model Analysis Results

Evaluation of Outer Model

a. Convergent Validity

The indicator is considered valid if it has a loading factor value > 0.70 (Rifa'i, 2015) and an Average Variance Extracted (AVE) value > 0.5. Based on the analysis results in *Appendix 4, 5,* and *Fig. 4*, it is known that the indicators are valid. This shows that each indicator is able to explain the effect on the latent variable by more than 70% and has high validity and accuracy.

b. Discriminant Validity

Discriminant validity aims to prove that a variable can predict the size of one block with another block. Discriminant validity can be seen through the cross-loading value approach. Assessment with this cross-loading approach contains the correlation value of the indicator to the construct, which requires it to be greater than the correlation value between the indicator and other constructs (Henseler et al., 2015). The cross-loading value of each indicator on the latent variables in the study showed > 0.7 *(Appendix 6*). This means that each construct had a high value concerning the latent variable.

Composite Reliability

Composite reliability (CR) measures the real reliability value and estimates the internal consistency of the latent variable and also calculates Cronbach's Alpha (CA) to measure the level of indicator reliability of the variable (Rifa'i, 2015). The results of the CR and CA analysis are presented in *Table 2*.

The CR value for all research variables was above 0.7, meaning the variables used in the study met the requirements of confirmatory research (Riptanti et al., 2022). The CA value of all variables was above 0.6, meaning these variables met a confirmatory and exploratory research. All variables have provided consistent and stable answers to test the hypothesis whether to provide new findings or confirm from previous research (Nilsen et al., 2020).

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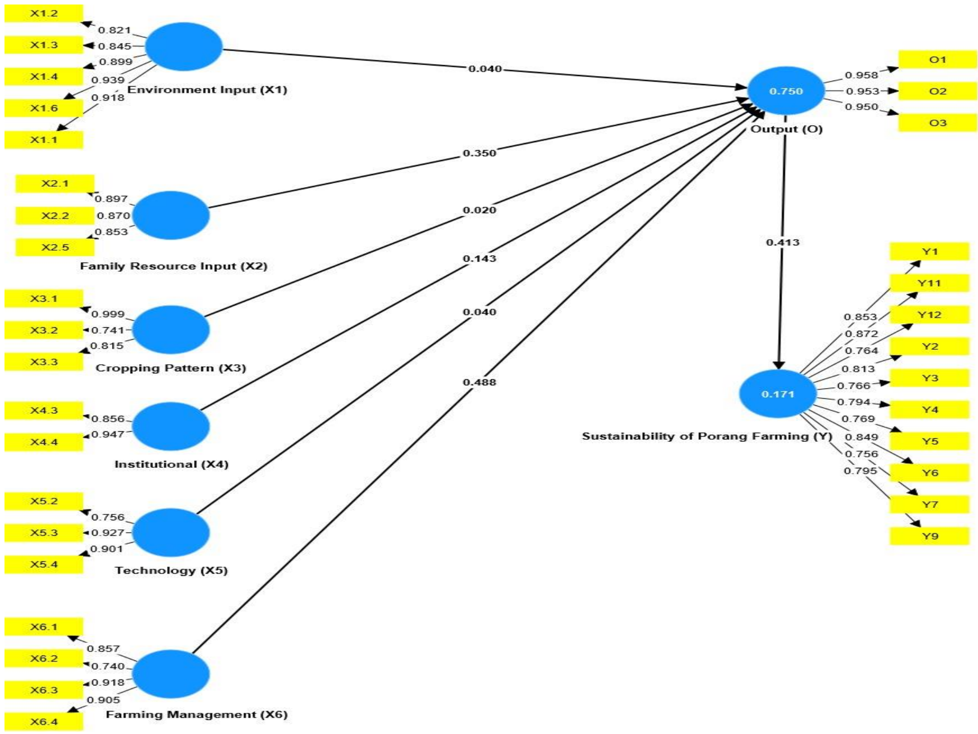

Figure 4. *PLS Modeling Path Diagram*

Table 2. *CR and CA Values*

Latent Variable	CR	CA	Description
X1	0.948	0.943	Reliable
X2	0.906	0.845	Reliable
X3	0.892	0.916	Reliable
X4	0.898	0.783	Reliable
X5	0.898	0.832	Reliable
X6	0.917	0.879	Reliable
O	0.968	0.950	Reliable
Y	0.948	0.943	Reliable

Source: Output WarPLS 6.0, 2022

Structural Model Evaluation (Inner Model)

Testing the structural model on the Output variable (O) obtained an R-square Output (O) value of 0.750, meaning it is categorized as strong (*Appendix 7*). This means that the independent variable (exogenous) used was good enough to explain the dependent variable (endogenous). This result was also strengthened by the Q2 value of 0.668. Meanwhile, the R-square value of the farming sustainability variable (Y) was 0.171, categorized as weak. The Q2 value was 0.080, which tends to be low even though it is greater than 0.02, which means this model can be used as a relevant estimator (Rifa’i, 2015).

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Hypothesis

The results of hypothesis testing using the bootstrapping method are presented in *Table 3*. Not all exogenous variables affected endogenous variables; therefore, not all hypotheses were accepted. Explanation of the hypothesis testing carried out.

Table 3. *Bootstrapping-Path Coefficients Results*

Variable	T Statistics	P Values
Environment Input (X1) → Output (O)	0.903	0.367
Family Resource Input (X2) → Output (O)	5.156	0.000***
Crop Pattern (X3) → Output (O)	0.456	0.649
Institutional (X4) → Output (O)	3.048	0.002**
Technology (X5) → Output (O)	0.503	0.615
Farm Management (X6) → Output (O)	5.024	0.000***
Output (O) → Porang Farming Sustainability (Y)	8.188	0.000***

Source: Output WarPLS 6.0, 2022, description: *** Significant α at 0.01; ** Significant α at 0.05

The explanation of the results of hypothesis testing is as follows:

H1: Environmental inputs affected the output of porang farming

The environmental input variable did not affect the output, so Hypothesis 1 was rejected. This result does not follow the results of Suhartini's research (2011), stating that good environmental quality will increase farming profits. Based on the altitude, porang can grow optimally in the lowlands to 1,000 meters above sea level (Mufidah et al., 2021). Meanwhile, some areas of Wonogiri Regency are classified as lowlands, and some are in mountainous areas. Although the area's height is different, the output produced in each sub-district is relatively the same. Areas with higher elevations tend to have higher rainfall (Soomro et al., 2019). High rainfall will cause the condition of the plants to be damp and susceptible to fungus. Meanwhile, diseases of porang plants are fungi. However, according to Yuniarsih (2021)], fungus is not a big obstacle for porang plants. The results showed that porang pests and diseases had no significant effect on crop yields. Farmers have knowledge and skills in controlling porang pests and diseases.

H2: The input of family resources affected the output of porang farming

The input variable of family resources has been proven to positively affect the output of porang farming. The results show that family involvement in porang farming is something that usually happens, so more family members will further reduce the need for workers outside the family (Pinem et al., 2022; Hamilton et al., 2022) land tenure (Akram et al., 2019; Fraval et al., 2020; Riptanti et al., 2021; Addaney et al., 2022); availability of farming capital (Barrera-Mosquera et al., 2010; Dermoredjo et al., 2021; Riptanti et al., 2022). Porang farming requires a lot of capital, so the status and area of land tenure are one of the main keys to the success of its cultivation. Farmers who own their land have the potential to increase their crop productivity. This indicates that farmers devote more time to porang farming (Moon et al., 2020).

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The use of family resource inputs is an important variable in porang farming. Workers within the family will reduce farming costs to increase profits (Kostov et al., 2018). The experience of farming porang farmers will improve their skills, knowledge, and understanding to solve problems in porang farming. On the other hand, the age of farmers in the old farmer group aged >35 years (Riptanti et al., 2022) is a mature age, getting more experienced and skilled in porang farming.

H3: Cropping pattern affected the output of porang farming

The cropping pattern variable did not affect the output, so Hypothesis 3 was rejected. This result was different from the results of research by Kamkar (2016) and Jones et al. (2021), stating that differences in cropping patterns impact farm yields. The Wonogiri Regency area has a lot of forest land (Hudiyani et al., 2017). Most farmers cultivate perennials, such as mahogany, teak, rosewood, and cloves. As the original habitat of porang, the forest causes this plant to be tolerant of shade (Ferziana et al., 2021) of perennials. Although there are still some perennials, the variations in cropping patterns applied tend to be the same because farmers only rely on what is in nature as a supporting factor for their porang cultivation. Farmers use a monoculture cropping pattern system that leads to open land, and many farmers interact with seasonal crops. Due to the lack of variation in cropping patterns, it is difficult to know which cropping pattern is more promising.

Farming inputs used by porang farmers in the form of fertilizers and pest and disease control were carried out naturally using livestock manure and rabbit urine. Almost all farmers used the same input, so there was no significant difference in yield. The natural treatment was based on the farmers' belief that porang can grow well without chemicals. According to Mufidah et al. (2021), organic treatment of porang plants can increase productivity and the content of active ingredients. On the other hand, organic farming is done accidentally because porang can grow well in the forest without or with special treatment.

H4: Institutional affected the output of porang farming

Institutional variables proved to positively affect the output of porang farming. The study results showed that the role of institutions was important in increasing the output of porang farming. This is in line with the opinions of Muro and Tridico (2008), stating that if the role of institutions, both social and economic institutions, is not optimal, the development of commodity agribusiness will also be hampered. The institution of the Wonogiri National Porang Farmers Association (P3N) plays a role in facilitating prospective porang farmers in farming by providing seeds. Regular training and monthly meetings discuss solving problems in cultivation and marketing. This can improve the ability of farmers in porang farming.

The role of research institutions is quite large in agriculture (Douthwaite et al., 2017), especially in technology transfer which is very important in supporting the productivity of porang farming (Mgendi et al., 2019). The research results on cultivation technology from seeds, fertilization, pest and disease control, maintenance, harvest, and post-harvest that research institutions socialize are very important in increasing porang output.

Porang, an industrial plant used as a raw material for the food and non-food industries, has a high export demand. The government has a significant role in facilitating exports (Riptanti et al., 2022) by facilitating porang land registration,

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organic land certification, and export tax reductions. This encourages farmers to do better farming to increase output and meet export standard requirements.

H5: Technology affected the output of porang farming.

The technology variable did not affect the output, so Hypothesis 5 was rejected. The research did not follow the results of the research on the use of technology plays a major role in farming, especially in technical efficiency (Venkatesh, 2016). The cultivation technology applied to porang farming in Wonogiri Regency tends to be the same, including seeds/seedlings, land management, fertilization, pest and disease control, harvesting, and post-harvesting. P3N Wonogiri plays an important role in transferring porang cultivation technology, so the success rate likely is the same. On the other hand, this shows the success of P3N Wonogiri's role in technology transfer to porang farmers who are members.

The seed technology used is still simple. The selection of seeds is only based on physical appearance including weight and buds. On the other, the quality of the seeds comes from sources whose quality is not guaranteed. The seeds have not been certified so that the quality of the seeds used is of less quality and not uniform. This has an impact on the achievement of results in quantity and quality (Handayani and Yuzammi, 2016).

The average labor of porang farming families in farming management is 2 people. Labor outside the family dominates in the management of porang farms. Porang farming in the research area has not yet implemented technological mechanization. Porang is sold in fresh form because the processing technology has not been mastered by farmers (Riptanti et al., 2022). This makes the porang processing industry at the farm level not develop.

Porang has a high selling value because of its glucomannan content used in pharmaceutical, food, cosmetics, textile, and other industries (Gusmalawati et al., 2021). However, almost all farmers sell porang in the form of corms. This is the cause of the insignificance of technology, so it does not produce added value. The processing technology into glucomannan flour has not been able to be applied by farmers for various reasons. One of them is limited capital in the procurement of technology.

According to Simanjuntak (2022), digital marketing of porang commodities is quite profitable because porang is a commodity that has a large enough market opportunity in the country. However, farmers prefer to sell porang corms to middlemen who come to their villages because they do not incur transportation costs. Farmers have calculated carefully if they sell to other traders using digital marketing. Still, the risk of transportation costs and depreciation is higher than the difference in the increase in their income. Farmers are more certain to sell to middlemen who come to them compared to selling to other traders outside the area through digital marketing.

H6: Farm management affected the output of porang farming

Farming management variables proved to have a positive effect on the output of porang farming, so Hypothesis 6 was accepted. The research results are in line with Q. Li et al. (2017), stating that as a manager, his role will determine the success of the business he manages. Farmers, as managers, will try to achieve optimal productivity and profit. This condition can be understood because porang farming requires a lot of capital, especially labor. Farmers must be able to manage limited capital to obtain optimal revenue. Farmers with the ability to manage their farms will be able to plan the

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amount of input needed. In the aspect of sustainability, the efficient use of agricultural inputs is part of managing both natural and human resources so that they remain available for a long time (Struik and Kuyper, 2017). Optimal use of inputs will provide optimal and consistent results, even increase when the internal and external conditions of the commodity are stable in the ecosystem (Oborny, 2004).

Porang cultivation requires many workers, especially at the treatment stage, because porang takes about three years to get the maximum quality and weight of corms (Riptanti et al., 2022). Manpower management is important in achieving economic efficiency (Chmieliński et al., 2022). The management of family and non-family workers must be optimized at every stage of porang cultivation.

According to Iqbal (2020), farms with good productivity will only succeed if the marketing goes well. Farmers must be able to determine the right planting time and harvest time so that when porang prices are high, they can sell their crops. This year's climate change conditions are difficult to predict because the frequency of rain is almost all year round. Farmers as managers must be able to adapt to this condition. Porang harvest is done when rain is not frequent because the glucomannan content will decrease, and porang corms will be undervalued in the market. Farmers must be able to determine the right harvest time in the position of high prices and low frequency of rain. Delays in harvesting affect the emergence of shoots on porang corms, so they are not good for use as industrial raw materials.

H7: Output affected the sustainability of porang farming

The output variable was proven to positively affect the sustainability of porang farming, so Hypothesis 7 was accepted. Farming results that are increasing in production will ensure the sustainability of porang farming. Farmers sell their crops in the form of bulbils and corms. Good quality of bulbil porang will affect the production of corms (Riptanti et al., 2022). This causes bulbil prices to be high in the market (Dermoredjo et al., 2021). The ever-increasing yields will excite farmers to manage porang farming well. Increased output can increase the capacity of farmers to provide inputs and operational costs so that porang farming is sustainable. The output variable significant to the sustainability variable of porang farming indicated that the output variable strengthened the influence relationship between exogenous variables indirectly on the endogenous variable of porang farming sustainability. The magnitude of this indirect effect needs to be investigated further. This is a limitation of the research results.

Conclusion

The sustainable porang farming model in Wonogiri Regency was built on the input variables of family resources, institutions, and farm management inputs that affect farm output. The output variable as an intervening variable directly influenced the increase of porang farming sustainability. Farmers as managers have an important role in determining the use of production inputs and combining them to increase porang production and productivity. Institutional roles need to be developed in supporting the sustainable development of porang farming, both at the farmer, community, marketing, and government levels. Each party plays its role according to its abilities and needs.

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APPENDIX

Appendix 1. *Instrument Validity Test (Loading Factor)*

Indicator	Loading Factor Value			
	Before Elimination	**After Elimination-1**	**After Elimination -2**	**After Elimination -3**
Climate suitability (X1.1)	0.821	0.822	0.822	0.822
Frequency of pest and disease attacks (X1.2)	0.776	0.783	0.783	0.783
Impact of pest and disease attacks (X1.3)	0.790	0.791	0.791	0.791
Land conditions (X1.4)	0.879	0.880	0.880	0.880
Water availability (X1.5)	0.699	-	-	-
Length of drought in rainy season (X1.6)	0.759	0.750	0.750	0.750
Land availability (X2.1)	0.965	0.959	0.959	0.959
Labor availability (X2.2)	0.803	0.816	0.816	0.816
Availability of farming capital (X2.3)	0.521	-	-	-
Age of farmers (X2.4)	0.470	-	-	-
Porang farming experience (X2.5)	0.854	0.865	0.865	0.865
Agroforestry system (X3.1)	0.940	0.941	0.941	0.941
Diversified farming system (X3.2)	0.709	0.709	0.709	0.709
Organic farming system (X3.3)	0.717	0.716	0.716	0.716
The role of establishing the porang community (X4.1)	0.164	-	-	-
The role of the porang processing industry (X4.2)	0.375	-	-	-
The role of research institutions in technology transfer (X4.3)	0.829	0.915	0.915	0.915
The role of the government in export facilitation (X4.4)	0.744	0.906	0.906	0.906
Seed technology (X5.1)	0.115	-	-	-
Cultivation technology (X5.2)	0.707	0.708	0.708	0.708
Post-harvest technology (X5.3)	0.936	0.935	0.935	0.935
Digital marketing technology (X5.4)	0.803	0.803	0.803	0.803
Capital management (X6.1)	0.862	0.863	0.863	0.863
Labor management (X6.2)	0.848	0.848	0.848	0.848
Marketing management (X6.3)	0.910	0.907	0.907	0.907
Post-harvest management (X6.4)	0.883	0.887	0.887	0.887
Porang tuber production (O1)	0.939	0.938	0.938	0.938
Production of bulbil (O2)	0.956	0.956	0.956	0.956
Farmers’ income (O3)	0.928	0.929	0.929	0.929
Use of frog tubers (Bulbil) at planting (Y1)	0.830	0.830	0.832	0.832
Availability of bulbil during the growing season (Y2)	0.798	0.801	0.802	0.802
Land elevation (Y3)	0.766	0.761	0.753	0.754
Availability of water at the beginning of the growing period (Y4)	0.809	0.813	0.807	0.807

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Indicator	Loading Factor Value			
	Before Elimination	**After Elimination-1**	**After Elimination -2**	**After Elimination -3**
Land conversion (Y5)	0.721	0.723	0.720	0.721
Porang tuber productivity (Y6)	0.867	0.869	0.873	0.873
Cost of porang farming (Y7)	0.819	0.814	0.806	0.806
Capital availability (Y8)	0.706	0.699	-	-
The role of the porang community in cultivation and marketing (Y9)	0.796	0.793	0.795	0.795
Porang marketing institutions (Y10)	0.698	-	-	-
Porang development policy (Y11)	0.801	0.807	0.814	0.814
Farmers' response to porang post-harvest technology (Y12)	0.763	0.762	0.759	0.759
Mastery of Good Agricultural Practices technology (GAP) of porang cultivation (Y13)	0.712	0.702	0.694	-

Source: Output Smart PLS 6.0, 2022

Appendix 2. *Average Variance Extracted (AVE) Value*

Variable	Average Variance Extracted (AVE)	Description
Environment inputs (X1)	0.651	Valid
Family resource inputs (X2)	0.778	Valid
Cropping pattern (X3)	0.633	Valid
Institutions (X4)	0.829	Valid
Technology (X5)	0.673	Valid
Farming management (X6)	0.769	Valid
Outputs (O)	0.886	Valid
Porang farming sustainability (Y)	0.636	Valid

Source: Output Smart PLS 6.0, 2022

Appendix 3. *Instrument Reliability Test Results*

Variable	Cronbach's Alpha	Composite Reliability	Description
Environment inputs (X1)	0.869	0.903	Reliable
Family resource inputs (X2)	0.865	0.913	Reliable
Cropping pattern (X3)	0.754	0.836	Reliable
Institutions (X4)	0.794	0.907	Reliable
Technology (X5)	0.760	0.859	Reliable
Farming management (X6)	0.900	0.930	Reliable
Outputs (O)	0.935	0.959	Reliable
Porang farming sustainability (Y)	0.939	0.946	Reliable

Source: Output Smart PLS 6.0, 2022

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Appendix 4. *Loading Factor Value for Convergent Validity Measurement*

Code	X1	X2	X3	X4	X5	X6	O	Y
X1.1	0.918							
X1.2	0.821							
X1.3	0.845							
X1.4	0.899							
X1.6	0.939							
X2.1		0.897						
X2.2		0.870						
X2.5		0.853						
X3.1			0.999					
X3.2			0.741					
X3.3			0.815					
X4.3				0.856				
X4.4				0.947				
X5.2					0.756			
X5.3					0.927			
X5.4					0.901			
X6.1						0.857		
X6.2						0.740		
X6.3						0.918		
X6.4						0.905		
O1							0.958	
O2							0.953	
O3							0.950	
Y1								0.853
Y2								0.813
Y3								0.766
Y4								0.794
Y5								0.769
Y6								0.849
Y7								0.756
Y9								0.795
Y11								0.872
Y12								0.764

Source: Output Smart PLS 6.0, 2022

Appendix 5. *AVE Value Calculation Results*

Code	Average Variance Extracted (AVE)	Description
X1	0.784	Valid
X2	0.764	Valid
X3	0.737	Valid
X4	0.814	Valid
X5	0.747	Valid
X6	0.736	Valid
O	0.910	Valid
Y	0.647	Valid

Source: Output Smart PLS 6.0, 2022

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Appendix 6. *Cross Loading*

Code	O	X1	X2	X3	X4	X5	X6	Y
O1	0.958	0.133	0.660	0.110	0.439	0.648	0.785	0.354
O2	0.953	0.133	0.713	0.121	0.412	0.580	0.753	0.444
O3	0.950	0.114	0.748	0.112	0.386	0.602	0.779	0.383
X1.1	0.123	0.918	0.147	0.202	0.021	0.139	0.059	0.021
X1.2	-0.006	0.821	0.004	0.107	-0.111	0.028	-0.017	-0.113
X1.3	0.027	0.845	0.021	0.161	-0.115	0.032	-0.042	-0.103
X1.4	0.077	0.899	0.096	0.341	-0.063	0.121	0.054	-0.115
X1.6	0.155	0.939	0.126	0.257	0.096	0.114	0.075	-0.045
X2.1	0.682	0.140	0.897	0.171	0.239	0.474	0.633	0.274
X2.2	0.641	0.084	0.870	0.107	0.188	0.458	0.610	0.174
X2.5	0.619	0.122	0.853	0.124	0.260	0.372	0.503	0.330
X3.1	0.127	0.279	0.161	0.999	-0.093	0.096	0.097	-0.018
X3.2	-0.002	0.133	0.019	0.741	-0.146	0.027	-0.038	-0.153
X3.3	0.012	0.158	0.038	0.815	-0.148	0.000	0.017	-0.136
X4.3	0.287	-0.015	0.161	-0.134	0.856	0.261	0.220	0.203
X4.4	0.461	0.053	0.287	-0.062	0.947	0.415	0.416	0.279
X5.2	0.373	0.048	0.282	0.104	0.185	0.756	0.467	0.205
X5.3	0.650	0.096	0.509	0.070	0.343	0.927	0.714	0.337
X5.4	0.582	0.176	0.457	0.071	0.444	0.901	0.697	0.191
X6.1	0.670	0.061	0.532	0.080	0.368	0.666	0.857	0.294
X6.2	0.533	0.045	0.607	0.166	0.049	0.435	0.740	0.177
X6.3	0.772	0.068	0.614	0.066	0.413	0.724	0.918	0.325
X6.4	0.770	0.043	0.561	0.036	0.384	0.679	0.905	0.322
Y1	0.456	0.001	0.272	-0.071	0.276	0.273	0.317	0.853
Y11	0.435	0.053	0.310	-0.008	0.310	0.292	0.374	0.872
Y12	0.150	-0.194	0.157	-0.116	0.104	0.128	0.151	0.764
Y2	0.308	0.041	0.200	-0.032	0.174	0.144	0.196	0.813
Y3	0.137	-0.093	0.113	-0.076	0.087	0.098	0.096	0.766
Y4	0.205	-0.030	0.149	-0.055	0.143	0.151	0.167	0.794
Y5	0.148	-0.101	0.076	0.023	0.172	0.155	0.132	0.769
Y6	0.490	-0.026	0.391	0.006	0.356	0.396	0.435	0.849
Y7	0.173	-0.127	0.145	0.024	0.053	0.157	0.137	0.756
Y9	0.274	-0.146	0.203	0.042	0.160	0.201	0.235	0.795

Source: Output Smart PLS 6.0, 2022

Appendix 7. *Determination Coefficient (R^2) and Predective relevance (Q^2)*

Code	R^2	R^2 Adjusted	Q^2
O	0.750	0.741	0.668
Y	0.171	0.166	0.080

Source: Output Smart PLS 6.0, 2022

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