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Do Small-Scale Farmers Want to Plant Sago Palm? An Empirical Analysis of the Factors Influencing Farmer Participation in Luwu Utara Regency, Indonesia

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Abstract: Despite the sago palm's significant contribution to village economies since early times, it has never been cultivated in a systematic manner by local farmers in Luwu Utara Regency, Indonesia. This study examines farmers' willingness to plant sago palm and the determinant factors influencing farmers' adoption behavior. A descriptive analysis and binary logit model were used for this paper. The results revealed that the majority of the respondents agree that replanting is generally important and they believe it to be of concern for every local farmer. The results further indicate that knowledge of an integrated cultivation system of sago, access to information and training, internal motivation, work experience, and the size of the sago area are the determinant factors influencing farmers to plant sago palm. The findings in this study could explain farmers' adoption of a better cultivation system plays an important role in the future of sustainable sago palm production.

Keywords: Cultivation; Participation; Determinant factors; Sago palm; Smallholders.

1. Introduction

Metroxylon sagu, known widely as sago, is a tropical crop containing a large amount of starch in its trunk with productivity four times that of paddy rice [1]. Mathur, *et al.* [2] stated that sago palm grows well in the tropical rain forests of Southeast Asia between latitudes 10º N and 10º S. Sago is a suckering tree with a massive rhizome that produces suckers freely, but it can also be propagated from a seedling [3]. Moreover, sago is also considered an eco-friendly tree and can help reduce global warming by producing 79.52 tons/ha of oxygen (O2) and absorbing 0.3% of CO2 per million ha of sago forest [4-6].

Sago palm mostly grows wild [7, 8] and Papua, Indonesia has been considered as a wild sago diversity center [9]. Numerous attempts have been made to develop cultivation of sago palm at the industrial level, but to date there has been no significant development even though sago has been recognized as a valuable resource since the early 1970s [10]. Schuiling, *et al.* [11] noted the development of the sago starch industries in Indonesia started by IHUTANI I at Halmahera in the Northern Moluccas with total production of around 6000 tons of dry starch when they visited the island in 1992. On the island of Benkalis, Riau, a considerable amount of sago palm is also cultivated on 3,000 ha and a new 20,000 ha planting will be developed over the next decade with a total of US$2 million/year expected to be invested in the new plantings [12]. Moreover, another private company, PT Sagindo Sari Lestari in Bintuni, Irian Jaya, operates a floating extraction factory with a production capacity of 36,000 tons, which is mainly sold as an extender in the production of adhesives for the local plywood industry [13]. In 2007, PT ANJ Agri Papua was established to develop sago processing operations in West Papua with over 40,000 ha to operate [14]. In 2010, an agriculture company, PT Sampoerna Agro Tbk, operated a sago plantation with a holding of over 85,000 ha in Riau and Papua [15]. In contrast, the sago industry in Sarawak, Malaysia is well established and has become an important industry contributing to export revenue [3]. Sago palm is concentrated in the river areas of Mukah District [16], which covers an area of 1.5 million ha or 12% of Sarawak's total land [17]. Since the 1970s, the Sarawak government has intensified efforts to develop the sago industry through the Sarawak Agriculture Department. The sago industry in Malaysia produces around 102,600 tons/year of starch [18]; Indonesian sago production is far below that at only 4.978 tons in 2013 [19]. Moreover, the development of the commercial sago plantation in Mukah is undertaken by the Land Custody and Development Authority (LCDA), which also runs sago

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research and development units [3, 20] as the world's first commercial plantation. Osozawa [4] argued that the development of sago in Malaysia and around Singapore has been consolidated by Chinese investors.

One critical aspect of developing the sago palm industry is the requirement to adopt practicable technology for production and management systems [21]. In Malaysia, for example, the state government in 2014 reported that investment in sago plantations by LCDA was unsatisfactory because the objectives were not yet achieved after a rehabilitation program experienced some problems and the results of the research were not yet adaptable [22]. Another problem is smallholder sago farmers. Sago farmers, especially in Indonesia, are still using conventional practices in sago processing and do not know how to cultivate sago palm. Osozawa [23] argued cultivation at the farmer level is difficult because sago plants are large, much bigger than a human body. The farmers are familiar with cultivating cereals, tubers, and vegetables, which are small. In addition, at the national level, there is no long-term comprehensive strategy that includes developing or promoting sago palm [24].

This paper presents an assessment of rural farmers' willingness to replant with sago palm and the determinant factors influencing farmers' adoption behavior. Thus far, researchers are still seeking to understand the driving factors of small farmers to plant sago palm, which is mainly driven by farmers who consider sago to be a forest plant that can be grown uncultivated [24] and lack of knowledge resulting in farmers producing inferior quality starch [25]. The present research is a case study involving only one regency of Indonesia. However, this study is the first to examine the driving factors of small-scale sago palm cultivation. The approach used in this research can be used in other regencies of Indonesia where enhancing sago palm is also based on community cultivation.

2. Methodology

2.1. Study Area

This research was conducted in July-August 2016 at Luwu Utara Regency, South Sulawesi Province, Indonesia (Fig. 1), which covers an area of 350 km2 with about 6,435 households. Luwu Utara is one of the main sago producers in Indonesia with a total land area of 1,635 ha, which can produce around 1,336 tons of crude sago [26]. This regency is also known to be affected by climate variability. According to the vulnerability to climate hazards index (Composite Climate Hazards Index (CCHI)), Luwu Utara is categorized as "Very High" in projections for 2020 and will subsequently be deemed as "Very High and Vulnerable" to climate hazards by 2050 [24, 27]. Thus, this indication place the regency in a category of very high vulnerability to hazard i.e. flood. Luwu Utara is also the pilot area for Sago Palm Restoration Project by Ehime University and Hasanuddin University, starting 2015 until 2018. The project was funded by the Ministry of Education, Culture, Sport, Science and Technology of Japan. Its main goal is to protect and rehabilitate sago palm, while at the same time meeting the socio-economic development for sustainable management of ecosystem. A sago seedling center and planting area was established to reach the project objective. Trisia, *et al.* [24] mentioned the positive results of this project are shown through the willingness of local government to endorse sago palm into the Luwu Utara Regional Medium-Term Development Plan (RPJMD) 2016-2020 as an alternative crop to adapt to climate change and providing land area to plant sago palm.

Figure-1. Map of Luwu Utara Regency, South Sulawesi, Indonesia

2.2. Methodology

In this study, 110 respondents aged 24-71 were surveyed. The survey was conducted throughout Luwu Utara, which was divided into three areas: Pengkajoang, Waelawi, and Tappong. These areas were selected for their high concentration of sago farmers. Both questionnaires and interviews were used with local farmers to define rural farmers' willingness to replant with sago palm and the determinant factors influencing farmers' adoption behavior. The questionnaire covered respondents' characteristics (age, sago area, work experience, total labor, and hazard experience) and determinant factors (knowledge, information and training access, internal motivation, and external support). The questionnaire was written in the local language (Bugis-Makassar) of the regency to effectively communicate the intent of the research.

Descriptive analysis was conducted to describe the basic features of respondents' characteristics in the study. Furthermore, logit regression analysis was applied to examine the variables that best explain variation in the measures of farmer perception and the factors influencing such decisions. The binary logistic model was used to analyze the determinants of the perception of sago farmers. The binary response variable *y* denotes two categories: 1 and 0 [28, 29]. The explanatory variable used in the logit models and hypothesized as a determinant of farmers' willingness to replant with sago palm is $y = 1$, and otherwise as $y = 0$. Assuming the probability of y = 1 is P, the function of y is as follows:

$$\boldsymbol{f(y) = P^{y}(1-P)^{1-y}, y = 0, 1} \quad (1)$$

We used the maximum likelihood estimation method to compute the regression parameter. The logit model's basic form is as below where *Pi* is the probability of *i* (the serial number of a farmer), *βj* is the regression parameter of influencing factors, *j* is the serial number of influencing factors, *m* is the number of influencing factors, *Xij* is the independent variable representing influencing factor *j* in sample *i, α* is the intercept, and *u* is the error.

$$\boldsymbol{P_i = F\left(\alpha + \sum^{m} \beta_j X_{ij} + u\right) = 1/\left(1 + Exp\left[-\left(\alpha + \sum^{m} \beta_j X_{ij} + u\right)\right]\right)} \quad (2)$$

The relationship between famers' characteristic variables and factor loading is as follows: farmers' willingness to replant with sago palm = *F* (age, sago area, work experience, employee ownership, hazard experience, factor loadings, etc.) + random disturbing factor. The method simply transforms *P*, which is strictly between 0 and 1, and obtains Logit (*y*) = ln [*P*/(1 − *P*)] [29]. The logistic model formula and independent variables are described below:

$$\boldsymbol{Logit\,(y) = ln\left(\frac{P_i}{1-P_i}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + + \beta_n X_n + u} \quad (3)$$

Combined with the above hypotheses about influencing factors, the factors affecting farmers' willingness to replant with sago include X_1 (farmer's age); X_2 (sago area); X_3 (work experience); X_4 (labor); X_5 (hazard experience); and *Xn* (farmer's driving factors) in replanting with sago palm obtained from factor analysis (Table 1). The logit model does not require stringent assumptions and is the ideal model for analyzing individual decision variables.

Table-1. Variable specifications

Variables	Description	Value	Source
Y	Willingness to plant sago	No = 0, Yes = 1	
Characteristic of respondents			
X_1	Age of the farmer (AGE)	24-30 years old =1, 31-45 = 2, 46-55 = 3, 56+ = 4	[30, 31]
X_2	Work experience (WO)	1–10 years = 1, 11–20 = 2, 21–30 = 3, 30+ = 4	[32, 33]
X_3	Sago palm area (SA)	0 = No land, 0.25–1.5 ha = 1, 2–3 = 2, 3.25 + = 3	[33, 34]
X_4	Employee ownership (EO)	No = 0, Yes = 1	[35, 36]
X_5	Hazard experience (HE)	No = 0, Yes = 1	[37, 38]
Driving factors of willingness to plant sago			
X_6	Knowledge of an integrated cultivation system of sago (KNO)		[39, 40]
	Seedling selection method (CS1)	No selection (CS1.1) = 0, Selected seedling without treatment afterward (CS1.2) = 1, Selected seedling from non-selected parent (CS1.3) = 2, Integrated seedling selection with selected parent and treatment afterward (CS1.4) = 3	
	Land preparation (CS2)	Not important (CS2.1) = 0, Important (CS2.1) = 1	
	Planting distance (CS3)	Not important (CS3.1) = 0, Important, distance 3-7 m (CS3.2) = 1, Important, distance	

		8-10 (CS3.3) = 2, Important, distance >10 (CS3.4) = 3	
	Pruning system (CS4)	Not important (CS4.1) = 0, Once in a while (CS4.2) = 1, Regularly (CS4.3) = 2	
X_7	Access to information and training (IT)		[41, 42]
	Sago cultivation information (IT1)	None (IT1.1) = 0, Information available (IT1.2) = 1	
	Source of information (IT2)	None (IT2.1) = 0, Parent/ancestor (IT2.2) = 1, Sago palm project (IT2.3) = 2	
	Participation in the sago replanting training (IT3)	Never participated (IT3.1) = 0, Yes, participated (IT3.2) = 1	
X_8	Internal motivation (IM)		[43, 44]
	Motivation related to economy (IM1)	Sago has liquidation value (IM1.1) = 0, Sago has investment value (IM1.2) = 1	
	Motivation related to land optimization (IM2)	Suitable for severe environmental conditions (IM2.1) = 0, Optimization of abandoned land (IM2.2) = 1	
	Motivation related to sago demand in the future (IM3)	Stagnant (IM3.1) = 0, Increase in demand (IM3.2) = 1	
X_9	External motivation (EM)		[45, 46]
	Assistance and support from government (EM1)	Not available (EM1.1) = 0, Available (EM1.2) = 1,	
	Regional regulation related to sago development (EM2)	None (EM2.1) = 0, Exist (EM2.2) = 1	
	Facilitation of sago marketing from government (EM3)	Not accessible (EM3.1) = 0, Accessible (EM3.2) = 1	
	Expected support from external parties (EM4)	Technical assistance (EM4.1) = 0, Facilities and equipment (EM4.2) = 1, Supervision and monitoring (EM4.3) = 2	

3. Results

3.1. Characteristics of the Respondents

The transformation of sago starch extraction by smallholders in Luwu Utara started a long time ago before the 1970s. In that time, local people extracted sago for their self-consumption using manual tools. In the end of 1970s, a rasping machine with diesel power had been introduced to extract sago. Between 1980s-1990s, water pumping had been initiated for a washing process to get better starch. In 2012, developed rasping machine, a washing process with better pump and extortion had been introduced in Luwu Utara for an efficiency of starch extraction. Nowadays, sago smallholders in Luwu Utara are categorized into 3 types based on technology adoption: (1) technology transition between traditional to small-scale, (2) small-scale technology and (3) semi-mechanized technology. Table 2 provides the difference of those types.

Table 3 shows the respondents can be divided into two groups: (a) willing (75.5%) and (b) unwilling (24.5%) to plant sago. Chi-squared tests showed there is a significant difference between the two groups in terms of age ($\chi2$ = 7.050, p-value < 0.10), work experience ($\chi2$ = 14.400, p-value < 0.05), sago area ($\chi2$ = 30.836, p-value < 0.01), and employee ownership ($\chi2$ = 5.022, p-value < 0.05). In terms of age groups, 32.7% of total respondents were in the group 24–30 years old, 37.3% were in the 31–45 group, 18.2% were in the 46–55 group, and 11.8% were older than 56. The ages of the "unwilling" respondents were categorized as a younger group 24–45 years old. On the other hand, the ages of the "willing" respondents were between 24 and 56+ years old. Furthermore, the majority of the "unwilling" respondents (85.19%) tended to have less work experience (1–10 years), whereas 53.01% of the "willing" respondents had more than 10 years' work experience. The data also revealed the majority of the "unwilling" respondents do not have a planting area (92.59%), whereas the "willing" respondents possess a sago plantation area of 0.25–1.5 ha and more than 3 ha (68.67%). Furthermore, the results showed the "unwilling" respondents have no employees (74.07%), whereas most of the "willing" respondents have employees (50.60%).

Although there was no significant difference between the two groups based on hazard experience (e.g., flood), the proportion of exposure was relatively high.

Table-2. Types of smallholders in Luwu Utara based on technology adoption

Type 1	Type 2	Type 3
Technology transition between traditional to small-scale technology: a. Cutting, chopping and rasping process are using machine, but the rest of the processes are done manually b. Business cost is provided by smallholders	Small-scale technology: a. Raspier machine is made by local people b. Water pump is modified to adjust the needs of sago processing c. Business cost is provided by smallholders	Semi-mechanized technology: Advance technology. The machine is made by local people with investment from businessman. Total investment is around IDR 50 million (USD 4,5000)
Number of worker: 1 person	Number of worker: 2-3 person, fixed and portable area (depend on the location of sago palm)	Number of worker: 5 person, fixed area

Table-3. Characteristics of the respondents

Characteristic	Sample size (%)	Respondent group (%)		Chi-Squared	Significance
		Willing to plant (83 respondents, 75.5%)	Unwilling to plant (27 respondents, 24.5%)		
Age (AGE), years					
24-30 years	32.7%	30.12%	40.74%	7.050	**0.070***
31-45 years	37.3%	33.74%	48.15%		
46-55 years	18.2%	20.48%	11.1%		
56 + years	11.8%	15.66%	0%		
Work experiences (WE)					
1-10 years	56.4%	46.99%	85.19%	14.400	**0.002****
11-20 years	19.1 %	20.48%	14.81%		
21-30 years	15.5%	20.48%	0%		
31+ years	9.1%	12.05%	0%		
Sago area (SA)					
No land	46.4%	31.33%	92.59%	30.836	**0.000****
0.25-1.5 ha	43.6%	55.42%	7.41%		
2-3 ha	8.2%	12.05%	0%		
3.25+ ha	1.8%	1.2%	0%		
Employee ownership (EO)					
No	55.5%	49.40%	74.07%	5.022	**0.025****
Yes	44.5%	50.60%	25.93%		
Hazard experience (HE)					
No	17.3%	20.48%	7.40%	2.437	0.118
Yes	82.7%	79.52%	92.60%		

*Significant at 10%, **Significant at 5%, ***Significant at 1%

3.2. Driving Factors of Willingness to Plant Sago

The farmers' driving factors to plant sago are divided into knowledge of an integrated cultivation system of sago (KNO), access to information and training (IT), internal motivation (IM), and external motivation (EM). Knowledge is defined as a set of understandings, capacity to imagine and perceive, and considered to be beneficial [47]. Figure 2 describes the discrepancy among farmers of different perceptions of knowledge of an integrated cultivation system of sago with respect to the willingness to plant sago. The sago cultivation guidelines from the Ministry of Agriculture [40] state that seedling selection method is important to give better results. L-shaped suckers, weight around 2–3 kg, and taken from a high production parent are considered the best seedlings. The data showed the "unwilling" farmers believed the seedling selection method (CS1.1) was not necessary (62.97%). Meanwhile, the "willing" farmers tended to understand more about the seedling selection method (39.75%) with proper treatment (CS1.4). For land preparation, the results revealed 74.07% of the "unwilling" respondents considered land preparation not important (CS2.1), whereas most of the "willing" respondents (77.11%) believed land preparation is necessary to achieve better production (CS2.2). Land preparation, such as clearing the land, and preparing planting holes and canals for the drainage system, must be done by farmers as well as providing a planting distance of about 8–10 m around each hole and pruning (Ministry of Agriculture 2014). About 81.93% of the "willing" respondents

indicated a planting distance of 8–10 m in planting sago was important (CS3.3). However, only 37.04% of the "unwilling" respondents indicated such a planting distance, whereas 51.85% indicated planting distance was not important (CS3.1). Furthermore, more than half the respondents agreed that farmers should prune sago palms once in a while (CS4.2).

The degree of information and training assessed in this study helps to understand if further efforts are required. The results of the driving factor information and training access (IT) are shown in Figure 3. Of the "unwilling" respondents, 59.26% admitted they have never obtained any information related to sago cultivation (IT1.1), whereas 62.65% of the "willing" respondents have information about sago cultivation (IT1.2). 43.37% of the respondents obtained such information from their ancestor/parent (IT2.2) and 18.52% from the sago development project (IT2.3). However, the majority of the respondents stated they have never participated in any kind of sago replanting training (IT3.1).

Figure-2. Knowledge of an integrated cultivation system of sago (KNO) and planting willingness

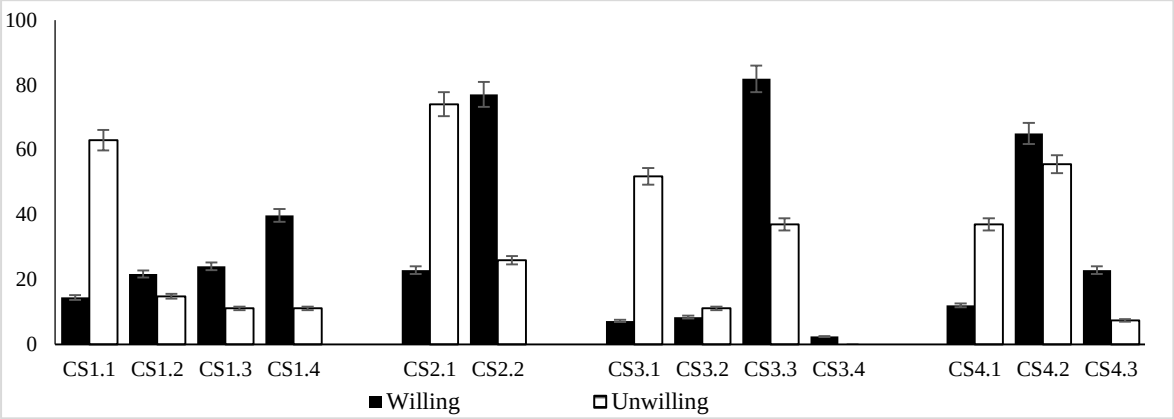
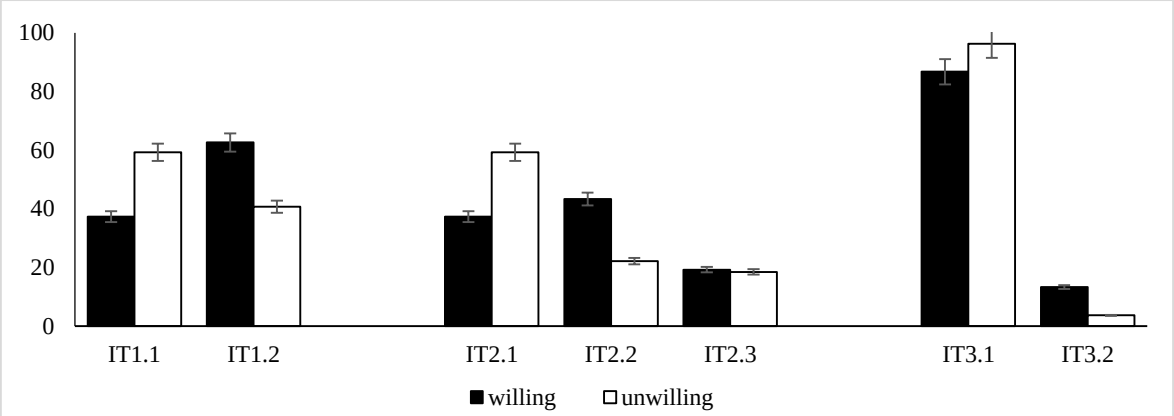


Figure-3. Access to information and training (IT) and planting willingness



The majority of the respondents from both groups agreed that growing sago has great benefit. Figure 4 shows 71.08% of the "willing" respondents believe sago has investment value for future benefit (IM1.2), whereas mostly 51.85% "unwilling" respondents chose the option of "sago has liquidation value (IM1.1)" as a motivation because it can be harvested anytime without any significant loss in starch content [5]. Meanwhile, for "motivation related to land optimization (IM2)", both groups agreed that sago can be planted under severe environmental conditions compared with paddy rice and could be planted to optimize abandoned land. For "motivation related to sago demand in the future (IM3)", most of the "willing" respondents (87.95%) believe sago demand will increase in the future (IM3.2), whereas for the "unwilling" respondents, the difference between sago demand will increase (51.85%) and sago demand will not increase (48.15%) was not significant.

As shown in Figure 5, most of both sets of respondents stated there was no assistance and support from the government (EM1.1). Only a handful of the "willing" (8.43%) and "unwilling" (3.7%) respondents referred to the sago seedling distribution program by the Department of Environment and Forestry of Luwu Utara as support from the government (EM2.2). All respondents also stated there was no regional regulation related to sago development (EM2.1). Meanwhile, all respondents agreed that "facilitation of sago marketing from the government (EM3)" was almost zero (EM3.1). Furthermore, almost half the respondents indicated that support from external parties should be facilities and equipment, supervision and monitoring, and technical assistance.

Figure-4. Internal motivation (IM) and planting willingness

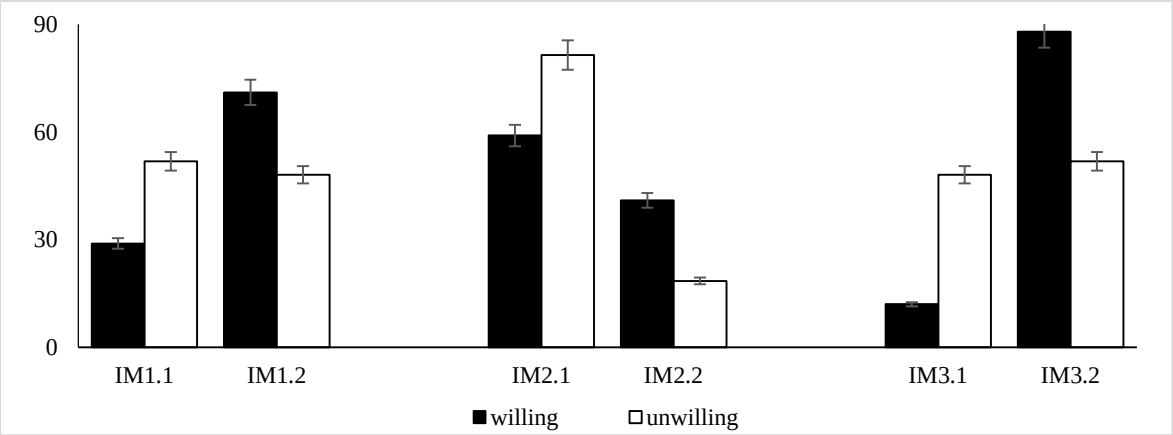
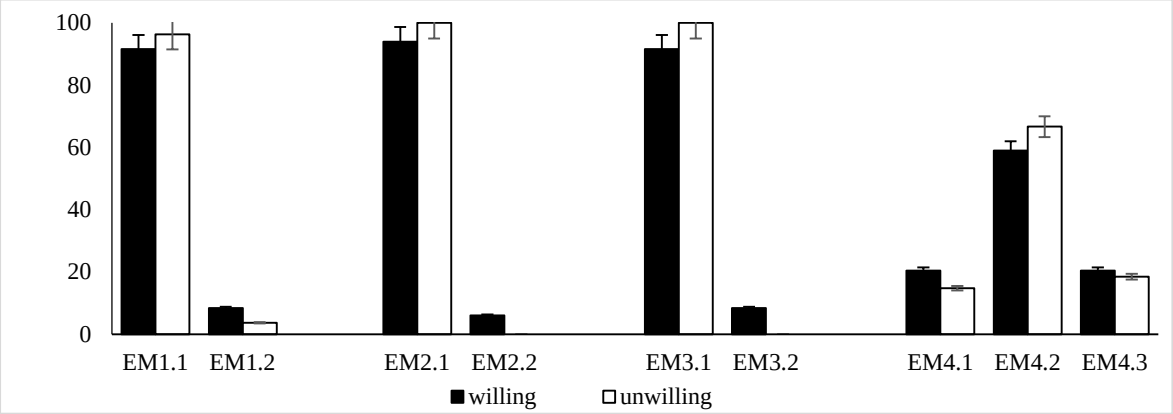


Figure-5. External motivation (EM) and planting willingness



3.3. Determinants Influencing Farmers' Willingness to Plant Sago

The binary logistic was used to estimate the determinant factors influencing farmers' willingness to plant sago. Table 4 shows the results of the model, including the coefficient (β), their standard error (*S.E.*), associated p-values (*Sig.*), and odds ratio (*Exp* (β)). The results showed a reduction from an initial −2 Log likelihood (122.603) to a final −2 Log likelihood (44.214) with 0.510 for the Cox and Snell R-squared value. This result means 51% of the variation in the dependent variables is explained by the model. Nagelkerke R-squared was found to be 0.758, which indicated almost 76% of the variation in the dependent variable was explained by the model. The observed significance level of the Hosmer and Lemeshow value was found to be 0.978, which is deemed an acceptable discrimination indicating an indifference between observed and predicted values.

Of the nine (9) dependent variables, only five (5) were found to be significant in affecting the farmers' willingness to plant sago: work experience (WE), size of the sago area (SA), knowledge of an integrated cultivation system of sago (KNO), access to information and training (IT), and internal motivation (IM). Meanwhile, age (AGE), employee ownership (EO), hazard experience (HE), and external motivation (EM) were revealed to have no significant effect on farmers' adoption behavior.

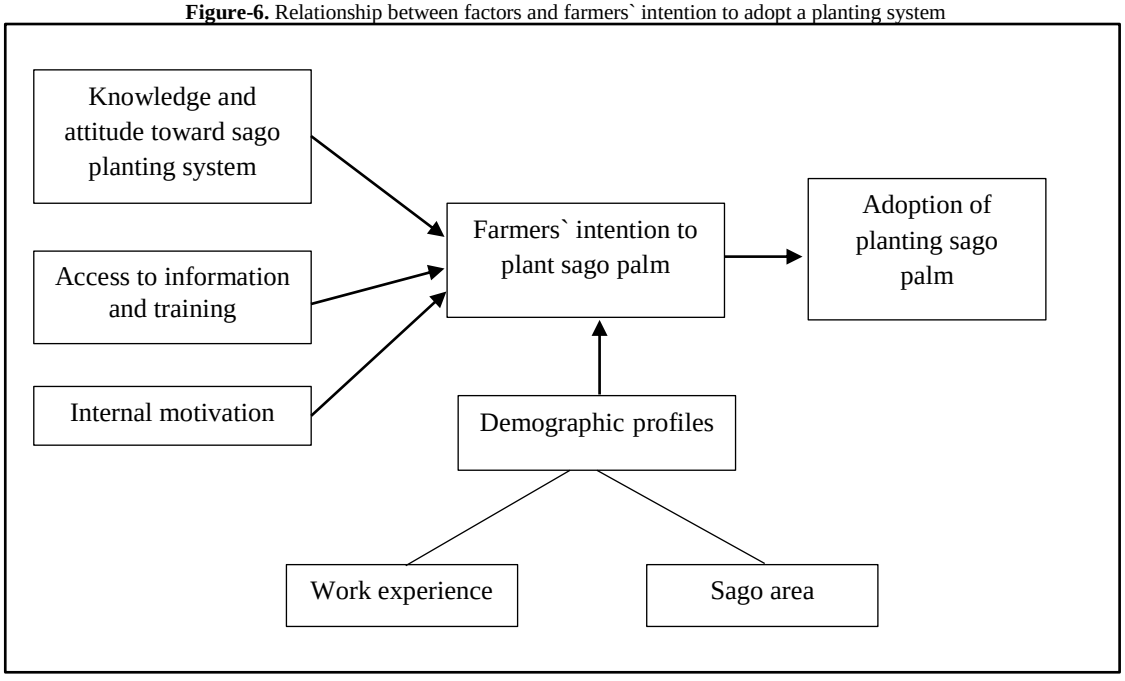
Table-4. Results of logit regression model

Variables	*β*	S.E	*Sig.*	Exp(*β*)
AGE	-1.109	0.880	0.208	0.330
WE	2.596	1.439	0.071*	13.415
SA	3.890	1.430	0.007***	48.898
EO	0.352	1.162	0.762	1.421
HE	1.462	1.608	0.363	4.313
KNO	5.464	1.639	0.001***	236.078
IT	-4.055	1.724	0.019**	0.017
IM	3.527	1.841	0.055*	34.039
EM	1.266	2.413	0.600	3.548
Constant	-8.447	3.223	0.009***	0.000
L_0 = -2 Log likelihood (initial)		122.603		
L_1 = -2 Log likelihood (final)		44.214		
Cox and Snell R-Squared		0.510		
Nagelkerke R-Squared		0.758		
Hosmer and Lemeshow Test		0.978		

4. Discussion

The results of this study showed that KN, IT, IM, WE, and SA are the determinant factors influencing farmers to plant sago palm. A better understanding of the relationship between the factors is highlighted in Figure 6. KNO has a positive coefficient, which indicates farmers who have more knowledge of an integrated cultivation system of sago are also more likely to plant sago. Several studies have pointed out that knowledge affects adoption of agricultural practices and innovations [39, 48]. Pierotti and Wildcat [49] emphasized that substantial knowledge can influence the willingness of individual rural landholders. In this case, having knowledge can be considered a positive factor allowing better implementation of planting sago. However, Naim, *et al.* [50] noted the main challenge in commercializing sago in Indonesia is the technological aspect. Sago palm cultivation in Indonesia is controlled by a big industry, which makes technology transfer and advisory services practicable for small farmers as priority options to be delivered.

Figure-6. Relationship between factors and farmers` intention to adopt a planting system



Our study found there is limited access to information and training in Luwu Utara; however, this lack of access does not diminish farmers' intention to participate. The internal motivation (IM) coefficient was statistically significant and positive, which indicates farmers with higher motivation tend to plant sago. Motivation is an interacting combination of an individual's goals, emotions, and beliefs [51], which moves from perception to action and achievement [43]. However, each farmer could develop different motivation processes because of their socio-economic status and experience, which influence their perception [44]. In this case, high motivation toward the economy, land optimization, and future demand for sago production may provide a guarantee of persistence from farmers to plant sago. This finding may explain why farmers are still willing to consider and adopt sago plantation, even though access to information and training barely exists at the field level.

Ghadim and Pannell [41] noted that adoption comes through a learning process, which can be categorized into two phases: (a) collection, integration, and evaluation of new information to make decisions about a new innovation; and (b) improvement in the skill of farmers to adapt better to their local situation. Furthermore, the Thematic Group on Sustainable Agriculture and Food Systems of the Sustainable Development Solutions Network [52] emphasized an effective information system is the key to implementing a successful sustainable agriculture program. However, in this study, sources of information on how to plant and cultivate sago are very limited. The information comes mainly from ancestors/parents and barely any from the sago palm restoration project without any appropriate training. Sajeev, *et al.* [42] indicated training is one crucial step to improve farmers' ability through enhancement of new skills, attitude, and knowledge to gain higher productivity. The best training program can be identified from an assessment of the needs of farmers [53]. Suggested topics for training assessment can be farming practices, sago palm production, economic management, and the value chain. Furthermore, extension workers from the state agriculture department play a vital role in facilitating and providing the required information [54] to ensure appropriate knowledge is implemented by the farmer to obtain the best result. The extension workers also need to ensure farmers understand this information and propagate new farming methods for the best sago production. However, the absence of extension workers who know about sago palm in Luwu Utara regency can be a challenge for the dissemination of sago palm information and access to training at the local level.

The positive estimated coefficient for WE indicates work experience is an important predictor of farmers' willingness to plant sago palm. This finding shows that the more experienced farmers are, the more likely they will plant sago. This result supports the empirical evidence of several studies indicating work experience determines farmers' adoption behaviour [32, 33]. Highly experienced farmers tend to realize sago palm production is decreasing gradually, which is influenced by their personal experiences and observations on sago production. According to data from the Department of Plantation of South Sulawesi, the sago area in Luwu Utara has decreased significantly by 23% from 2007 to 2014 (from 1,835.75 ha in 2007 to 1,420.12 ha in 2014). Trisia, *et al.* [24] found the absence of rejuvenation/re-planting of sago palm and the expansion of other profitable crops such as cocoa and orange during 1990–2000s are reasons why the sago palm area is decreasing. Therefore, involving experienced farmers to support a better cultivation system can also play an important role in sustainable production.

The respondents characteristic SA was shown to be statistically significant and positively related to farmers' willingness to plant sago palm. Farmers who own more land are more likely to plant sago and vice versa. The probable reason for the positive relationship is that planting sago is subject to economies of scale. Larger sago land appropriation could lead to larger benefits such as greater production, bigger income, and more capacity to bear risks in adoption or innovation [55-57]. Also, if large-scale cultivation is an advantage, then the government should support implementation of land reform such as farmers' cooperation in cultivating a large-scale field [34] and optimization of abandoned land or communal land to support farmers who do not have land.

It is commonly believed large-scale agricultural industries are needed to achieve high production [50]; however, several studies have revealed smallholder production causes minor damage to the environment, is more flexible, more efficiently uses labour, and is better at adapting to local surroundings and changing conditions [35, 36, 58]. Therefore, empowering smallholder farmers is important, especially in Indonesia because sago farms are mostly operated by small-scale farmers. The introduction of efficient sago farming and farming design through the integration of modern planting methods with traditional methods and the introduction of the best sago variety seedlings are important steps. Moreover, Watson [59] emphasized small-scale farmers should be assisted with the following: (a) new and innovative public-private partnerships, (b) increased public investment in research, and (c) development-oriented local governance and institutions including establishing farmer cooperatives and organizations.

This study revealed farmers are increasingly interested in planting sago, but there are challenges in adopting a better cultivation system. Table 5 provides a summary of the suggested actions to address these challenges that play an important role in the future of sustainable sago palm production. In this study, we showed participation of a farmer in cultivating sago positively correlates with knowledge. For that reason, there is a need to prioritize the promotion of a sago cultivation system. Technological innovation along with elaboration of modern and traditional methods of cultivating sago can address the lack of farming knowledge. Limited information and training are also important barriers revealed in this study. Thus, empowering farmers together with the availability of extension workers is necessary to support smallholders. Furthermore, fostering involvement among government, academia, and industry, and creating a regional/district virtual market can address issues related to market access and supporting policy. The last barrier, the lack of a promotion budget and financial support, can be overcome by actions such as increasing the provision of rural credit to farmers and providing subsidies to farmers to practice sustainable sago palm production with better management and equipment.

Table-5. Suggested action to address issues related to sago palm cultivation by smallholders

Barrier	Action	Mechanism
Lack of knowledge and traditional farming approach	Increase research and development on seedling variety and technological issue	Increase funding for further research and development, particularly combining academia and the private sector
	Further elaborate both modern and traditional methods in the farming process	Validate procedures and guidelines established for efficiency of sago palm cultivation
		Introduce certification schemes to ensure quality
Limited information and training for farmers	Provide high-quality information and training	Empower farmers through co-operatives/organization
		Make trained agricultural officers available to provide extension services
Poor market access and supporting policies	Foster involvement of government, academia, and industry	Streamline regulations to promote sago palm
		Bring effective communication between stakeholders
		Establish sago board under government institution
	Create regional/district virtual market or trading platforms	Create well-functioning market channels
Lack of promotion budget and financial support	Commit to invest in sustainable approaches for sago palm production	Increase the provision of rural credit to smallholder farmers
		Subsidize farmers for better equipment and management

5. Conclusion

The role of sago palm is considered highly important in providing income and food for the local community of Luwu Utara. Our results provide valuable information on the factors influencing farmers' willingness to plant sago palm, which can be used to promote sago cultivation in Indonesia. The most important factors are (1) knowledge of an integrated cultivation system of sago, (2) access to information and training, and (3) internal motivation, followed by (4) work experience and (5) size of the sago area. This study also found technology, information, and market access issues limit the development of sago palm cultivation by smallholders, next to the application limit set by the government.

The cultivation of sago palm cannot be accomplished by one person alone. Success requires active participation by the government, industry, academia, and farmers. Therefore, recommendations can be derived from the findings in this study. First, it is necessary to have effective communication between related stakeholders to avoid misconceptions. Second, it is important for smallholders to increase sago production in both quantity and quality. To achieve this, assistance should be provided by a mix of industry, government, and academia, i.e., sago palm restoration project removes technological barriers to the desirability of the product, finds the best sago variety, and increases institutional support. Educational services for practical applications such as a seedling training program, sago cultivation, and a management system as well as an internship program can be provided to build high quality small enterprises by local farmers. And finally, fostering social capital such as active participation by the local community is a key to the future of sustainable sago palm production. Self-organizing communities that effectively use their social capital based on trust and co-operation become more sustainable, effective, and resilient than those with mechanisms designed and imposed externally.

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