Accelerated adoption of sugar palm farming technology to supports sustainable resource utilization in North Sulawesi

J B M Rawung1,*, J G Kindangen1, R Indrasti2 and A Gaffar3

1 The Assessment Institute for Agricultural Technology of North Sulawesi, Manado, Indonesia.
2 Centre of Assessment and Technology Agricultural Development, Bogor, West Java, Indonesia
3 The Assessment Institute for Agricultural Technology of Maluku, Ambon, Indonesia.

* E-mail: jbmarkusrawung2000@yahoo.com

Abstract. The purpose of this study was to examine the characteristics and opportunities of accelerating the adoption of palm sugar farming technology in sustainable resource use in North Sulawesi Province on July to November 2016. The data used are secondary data and primary data derived from respondents as many as 120 palm-based farming households in the central district of palm plantations in Tareran, Tomohon, and Motoling. Analysis used cross tabulation for farmer characteristics and binary logistic regression approach for accelerated adoption opportunities. The results showed that the farmers cultivated sugar palm plants with an intercropping farming system with a variety of plantation and forestry food crops. Good knowledge of palm plant cultivation system (64.84%) in cultivating sugar palm with a good understanding of the sustainability of palm plant-based farming. Opportunities for accelerating the appreciation and adoption of farmers to sugar palm-based farming technology can be realized in the form of participatory technology assistance on all technology components, both basic and optional technology, by expanding the business scale, increasing various processed products, bringing the location of farming closer to residential and information sources technology. To increase the production of aren and their derivative products and to maintain the continuity and preservation of the environment, it is necessary to cultivate and expand the palm area in harmony with regional spatial planning for conservation and sustainable management.

1. Introduction

Arenga pinnata MERR (Arenga pinnata MERR) is one of the multipurpose plantation crops because almost all parts of the plant have benefits and high economic value. Agronomically, this plant is able to live in the lowlands to the plains with an altitude of 1500 meters above sea level and grows optimally at an altitude of 500-800 meters above sea level with a minimum evenly distributed rainfall of 1200 mm a year. The spread and growth of sugar palm (Aren) generally takes place naturally and can grow well in mountainous areas, valleys, near rivers, springs and is commonly found in forests [1,2]. This plant is one of the most potent plantation crops for use in tackling land degradation and reforestation, because it can grow well in various ecosystems, tolerates mixed cropping patterns, grows relatively fast, has dense roots and canopy, and does not require intensive maintenance making it suitable for use on marginal land, and the result can be a source of additional income for local farmers who generally have limited income.

In general, sugar palm still grows wild in several areas including North Sulawesi and even though it has been cultivated by farmers, it is not optimal because most of it is still part-time and still depends on
the dominant commodity. In fact, this sugar palm plant still grows wild on the slopes or riverbanks. The cultivation of palm trees in Indonesia has actually been going on for a long time, because Indonesia is one of the regions of origin of sugar palm, but its development into an agribusiness commodity is still slow. This is because most of the sugar palm population has not been cultivated. Palm cultivation has only been carried out in a small number of areas in North Sulawesi, Maluku, East Kalimantan, West Java and Banten [3, 4]. Sugar palm plantations in central areas generally spread sporadically. Sugar palm has begun to get serious attention from various parties in the last ten years to be developed into an agribusiness commodity. Aren turns out to be able to produce about 60 types of products with economic value and some have the potential for export. One of the mainstay products of palm plants, namely palm sugar, either in the form of printed sugar (brown sugar), sugar or crystal sugar. Sugar palm also acts as an energy supplier (bioenergy) and a component of environmental conservation [5]. The intensity of sugar palm planting is increasing and utilizing forest areas and mountainous slopes. Data from 2008 in the Forestry and Plantation Office of Tomohon City stated that the area planted with palm sugar in Tomohon City was around 981.27 ha and in South Minahasa District it was 1,613.2 ha (2006). So whether consciously or not, the behaviour of farmers with initial awareness to lead to the sustainability of their farming is already owned. As a conservation plant, planting sugar palm certainly makes an important contribution to forest conservation and soil conservation. Traditional processing technology produces limited consumer products such as brown sugar, kolang kaling and vine sugar or alcohol. As a result, the role of this sugar plant in the national economy is not prominent so that the attention on the development of this commodity is inadequate. Motivation of farmers in optimizing palm-based farming has not been clearly identified, including the factors that influence farmers in adopting technology. The purpose of this study was to examine the characteristics and identify the factors that influence farmers to adopt sugar palm farming technology. By knowing the characteristics of sugar palm farmers and knowing the factors that influence farmers in adopting cultivated sugar palm farming technology, it is hoped that the development of palm plants in the future will be more widespread and be calculated as a commodity that brings benefits to farmers in sustainable management.

2. Methods
The research was conducted from July to November 2016 in the central district of palm sugar farming in Tareran, Tomohon, and Motoling, North Sulawesi Province. The purpose of this study was to examine the characteristics and opportunities of accelerating the adoption of palm sugar farming technology in sustainable resource use in North Sulawesi. The data used primary data derived from respondents as many as 120 palm-based farming households. Data analysis used cross tabulation for farmer characteristics and binary logistic regression approach for accelerated adoption opportunities, where the adoption gap is the dependent variable and 15 other variables are independent.

To determine the factors that influence the adoption of sugar palm technology by farmers, logit regression analysis is used. According to [6], logistic regression can facilitate understanding of research so that the discussion will start with the simplest logistic regression model, namely the model without predictors or zero regression, which will form the basis of the next model. [7] states that logistic regression analysis is a probability modeling research technique. In detail, the use of this logit function has been described and discussed by [8’ 9, 10, 11]. The logit function model formula can be formulated as [12,13]:

Regression model formulation  \[ P_i = \frac{1}{1 + \text{Exp}(-Z)} + e_i \]  

\[ \text{................. (1)} \]

In logarithmic form, the equation can be written as follows:
\[
\ln \frac{P_i}{1 - P_i} = \alpha + \sum_{j=1}^{n} \beta_j X_{ji} + \sum_{k=1}^{m} \gamma_k D_{ki} + \epsilon \tag{1 - P_i}
\]

- \( P_i \) = Opportunity for farmers to apply technological innovations faster.
- \( P_i = 1 \) if the farmer adopts the innovation for less than one year,
- \( P_i = 0 \) if farmers adopt the innovation for more than one year
- \( 1 - P_i \) = Opportunity for farmers to adopt the innovation for more than one year
- \( \alpha \) = Constant

\( \beta_{nxjn} \) = independent variable in certain units is arranged as follows:
- \( X_j \) = independent variable vector (\( j = 1, 2, 3, \ldots n \))
- \( D_k \) = dummy variable vector (\( k = 1, 2, 3, \ldots n \))
- \( \alpha, \beta_j, \) and \( \gamma_k \) = estimated parameters of the logistic function
- \( \epsilon \) = random error

The model includes adoption acceleration as the dependent variable. There are 15 independent variables in the model, including two dummy variables in it. The free variables are as follows:
- \( X_1 \) = Age of farmer (years), \( X_2 \) = Basis of formal education (years), \( X_3 \) = Farming experience (years), \( X_4 \) = dependents of the family (soul), \( X_5 \) = scale of business (ha), the area of farm land owned, \( X_6 \) = Distance from farm to settlement (km), \( X_7 \) = Distance of settlement to main technology source /AIAT (km), \( X_8 \) = Distance of settlement to the nearest information source (Regional Agriculture Service Office) (km), \( X_9 \) = Distance from settlement to source of capital (km), \( X_{10} \) = Distance from settlement to market (km), \( D_1 \) = infotech flow (category 1 = short, less than three knots); category 0 = other), \( D_2 \) = land tenure status (category 1 = owner, category 0 = other (not owner).

The completion of the logit function estimation is done by using the Maximum Likelihood method using SPSS version 17 for windows. To determine the effect of independent variables used in the model together on dependent variables, the test is used at the 95% confidence level. The chances of farmers applying technology are faster to predict based on the Odds Ratio coefficient value derived from the formula:

\[
\hat{Y} = \frac{ODDS \times 100\%}{1 + ODDS} \quad \text{Odds} = \exp^{abx}
\]

\( a \) = constant; \( b \) = the coefficient of the x-variable. In the output of the SPSS version 17 program, the Odds Ratio coefficient is identical to the Exp (B) coefficient which can be interpreted as an opportunity in percentage units. It is based on the obtained coefficients calculated using the formula:

- \( \hat{Y} \) = prediction of chances of accelerated adoption
- In testing the hypothesis, the following criteria are used:
  - (a) If the P-value <\( \alpha \), then Ho is rejected. This means that the opportunities for farmers to adopt innovation more quickly (<1 year) are influenced by the independent variables formulated in the model.
  - (b) If the P-value >\( \alpha \), then Ho is accepted. This means that the assumed independent variable has no effect on the opportunities for farmers to adopt innovation more quickly.

3. Results and discussion

3.1. Characteristics of Respondents and Adoption of Palm Plant Farming Technology

Characteristics of individual respondents that are suspected of being associated with technology adoption were identified consisting of age, education, family dependents, and land tenure status. From the results of the interview, it was revealed that the age of the adopter varies from the youngest 21 years to the oldest 48 years. Judging from that age range, overall adopters are in productive age. This means
that the opportunity to increase farm productivity is quite large. Even if we look at the grouping, the majority (63.3%) of the total adopters are in the very productive age range, namely 21-40 years. In addition to support for productive age, all adopters have a formal education base of 5-12 years, 60% of whom have a junior high school level education and above (9-12 years). With the basis of formal education like this will strengthen the capability of farmers in running farming.

**Table 1. Characteristics of sugar palm farmers**

| Respondent characteristics | Minimum | Maximum | Average |
|----------------------------|---------|---------|---------|
| Age (years)                | 21      | 48      | 33,3    |
| Education (years)          | 5       | 12      | 9       |
| School-age dependents (persons) | 0  | 5       | 1,2     |
| Dependent family of working age (person) | 0  | 6       | 2,2     |
| Farming experience (years) | 1       | 28      | 17,3    |

In relation to the number of family dependents, adopter identification can be divided into school age (<15 years) and working age (>15 years). This distinction relates to support for family labor (for working age) and workload (for non-productive age). The working age group is a potential workforce on and off farm. On the other hand, the pure school age group is a burden on the family. The description of the characteristics of the respondents can be seen in Table 1.

Farming experience ranged from 1-28 years with an average of 17.3 years. Farmers think that farming experience for more than 10 years already has a fairly good basis for cultivation. They are able to solve and find solutions to farming problems based on their empirical experience. With this experience capital, farmers have experienced a dynamic mindset in adopting technological innovations. The acceleration of the adoption of this technology is being carried out by farmers who want to increase the production and added value of palm-based farming.

Table 2 shows that almost all respondents have good knowledge in terms of cultivating sugar palm. In some places, especially those with a habit of making sugar or consuming alcoholic drinks, sugar palm has often been planted deliberately, although generally as a peripheral or intercropping plant between existing tree crops. The types of plants found in palm oil plantations in the field are plantation crops (cloves, coconut, coffee, cocoa, nutmeg, cinnamon and vanilla), fruit trees (avocado, durian, langsat, duke, rambutan, longan, jackfruit, mango, banana), forestry plants (campoman, nandu, gemmal, senton, gmelina, and mahogany) and food crops (corn and peanuts). Of the various types of plants, there are 36 palm-based farming patterns developed by the respondent farmers. All identified farming patterns can be grouped into three types of farming patterns, namely (1) sugar palm is integrated with food crops, (2) sugar palm is integrated with various non-timber plants and (3) sugar palm is integrated with woody plants. The component that is still weak is the selection of seeds from superior palm types. The yield of sap from superior palm types can reach 15-20 liters/day or equivalent to 3-4 kg of sugar/day/tree.

**Table 2. Respondents Knowledge component of cultivating**

| No. | Knowledge Components | High Respondent | Middle Respondent | Low Respondent |
|-----|----------------------|-----------------|-------------------|---------------|
| 1   | Requirements growth  | 96              | 14                | 10            |
|     |                      | 80,00           | 11,67             | 8,33          |
4. Conclusions
The adoption gap from when farmers know about new technology to implement it on farms as a proxy for accelerated adoption ranges from less than 1 year to more than 4 years. There are five independent variables that partially affect the acceleration of palm farming technology adoption (Wald value > 0), namely business scale, distance to settlement, distance to BPTP, distance to the nearest information source, and land tenure status, two of which have a negative effect, namely distance to BPTP and to the nearest information (BPP). Each additional planting area of 1 hectare, there is an opportunity for farmers to accelerate technology one fold. Likewise, the distance to the settlement, the reduction in the distance from the farm to the settlement of 1 km has the opportunity to accelerate adoption six times. The increasing distance to BPTP and to BPP as the closest source of technology information has the opportunity to slow down adoption by 1.8 times and 0.2 times, respectively. With regard to land status, owner farmers will adopt faster technology than farmers with non-land owner status.

The implication of the results of this study recommends that the acceleration of farmers’ appreciation of palm sugar farming technology be realized in the form of participatory technology assistance for all basic and optional technology components. The gap in technology adoption is focused on effective extension methods and seeking assistance in the form of price guarantees and a pro-farmer market. Opportunities for accelerating the adoption of technology can be done by expanding the scale of the business, closer to the location of the farm and settlements and bringing farmers closer to sources of technological information.

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