International Journal on Advanced Science Engineering Information Technology

Vol.13 (2023) No. 5
ISSN: 2088-5334

Rice Food Security on Small Farmer Households Under Current Mechanization Level in Kampar Region, Indonesia

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***Abstract*— Rice is Indonesia's most important staple food and has become a key indicator of the country's food security. In Kampar Region, most small farmers face challenges in meeting their households' rice food security under a relatively limited application of mechanization and small farm scale. This study examines the rice food security status of small farmer households under current levels of mechanization in Kampar Region, Indonesia. Field surveys were conducted in two districts, Bangkinang and Kuok in Kampar region in April-June 2020. A total of 72 small farmers were purposively selected for the sample, of which 36 were farmers from each district. Data were collected through interviews using semi-structured questionnaires and analyzed using descriptive-quantitative techniques. As a result, the current mechanization application was classified as intermediate level. At this level, 1.33 tons of rice were produced, and the cultivated area was 0.37 ha on average. Rice productivity averaged 3.56 tons. ha^{-1} and varied with various farm sizes. The per capita rice consumption was still high, approximately 114.6 kg per year, and it requires a farm size of 0.054 ha to meet annual rice consumption, or 0.27 ha for households with 5 family members. About 46% of small farmers could not meet their rice needs within one year. They could supply rice for less than 12 months and up to 21 percent of them could supply rice for up to 6 months. Therefore, the level of mechanization must be increased to improve rice productivity.**

***Keywords*— Rice food security; small farmer households; mechanization level; rice productivity.**

Manuscript received 22 Dec. 2022; revised 19 Jan. 2023; accepted 14 Jul. 2023. Date of publication 31 Oct. 2023.

I. INTRODUCTION

Rice is widely known as one of the three staple food crops - rice, wheat, and maize - in the world. It is a staple food crop for approximately half of the world's population [1]. Human consumption of rice accounted for 78 percent of total rice production, while wheat accounted for 64 percent and maize for 14 percent [2]. Rice accounts for approximately 19 percent of global calorie consumption per capita and 27 percent in low- and middle-income countries [3], providing 13 percent of protein per capita. In Indonesia, about 55% of energy consumption comes from rice, as shown in Figure 1, and the amount of energy consumption has not changed significantly in the past five years [4]. These data show the importance of rice as a source of energy consumption in Indonesia. In addition, rice is a very important staple food for about half of the world's population [5] for food security, income generation and poverty alleviation in many developing countries. In the contrary, food insecurity is also acknowledged as a determinant of migration [6, 7], and mental health and depression [8].

Food security and safety are complex in developing countries [9]. Food security is ensuring adequate daily food that is reasonably priced, nutritious, and hygienic [10]. The food security concept is defined by four pillars (dimensions): availability, accessibility, utilization, and stability [11], [12], and these pillars have never been at a higher level, especially in the Asia-Pacific region. The current issue of food security is dominated by the availability of food, especially rice food, in the rural community. Food availability for rural households means ensuring they can provide enough food through their own production or purchasing from the market. Food availability concerns the supply side of food security and is determined by the level of food production, storage, and rice trading. Moreover, several approaches can be done to achieve sustainability and food security, like limiting food losses and waste by eating more plant-based foods, or recycling foodstuffs [13]. Achieving food security remains a challenge

in other parts of the world [14], especially for agrarian communities in low-income countries [15].

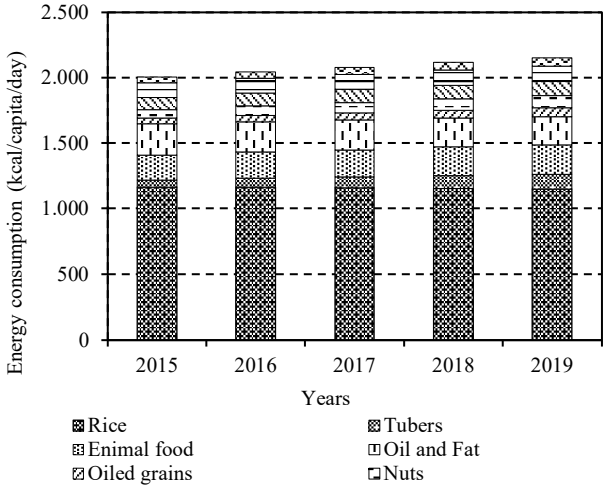

Fig. 1 Number of energy consumption from various sources in Indonesia [8].

Like other countries in the world, rice is the most important food crop in Indonesia as a source of livelihood and the most important staple food for more than 90 percent of the Indonesian population. The importance of rice as a staple food in Indonesia can be recognized by the country's higher consumption of rice, which was approximately 94.47 kg per capita per year in 2019 [16] compared to people in South Korea who consume 40 kg, Japan (50 kg), Thailand (70 kg) and Malaysia (80 kg) [17]. Indonesia's high rice consumption since this food is a main energy source and protein source. Rice contains 360 calories of carbohydrates and 6.8 grams of protein [18]. Therefore, the provision of adequate rice food at the household becomes a key indicator of food security throughout the country.

Land is the most important factor in agricultural production in developing countries [19], affecting land used for food production and security [20]. Other factors, such as seeds, fertilizers, labors, and pesticides, affect rice production [21,22] and productivity [23]. Thus, maintaining rice production at an adequate level at the household level remains a major challenge in Indonesia due to land degradation, land fragmentation, and high conversion of land to other uses. Land fragmentation affects productivity and food security of smallholders [24]. In addition, changing land use for cash crops such as palm oil also reduces the area of land used for food production and ultimately affects food security [25].

On the other hand, the demand for rice will continue to grow in the future, as the population grows at 1.2% per year and the demand from the food industry increases. Satisfying the demand for rice requires a conscious effort that ensures the availability of rice food primarily to feed the population and supports food security. Therefore, an increase in agricultural productivity positively affects rice production and is expected to ensure household food security [26]. In fact, most of the rice farms cultivated by farmers have become increasingly small and with relatively low productivity, which later became an important constraint to increase rice production. However, small-scale rice farmers play an important role as rice suppliers, as about 73 million tons of the national rice production in Indonesia is produced by small-scale farmers with 0.25-0.50 hectares of land.

The agriculture plays a fundamental role in food security but is highly vulnerable to climate variability and change [27] The current climate change poses a major threat to global food security around the world [28] and agricultural growth and production [29], [30]. Climate change affects rice production by increasing temperature, changing rainfall, water retention and soil fertility [31]. A decrease in yield is associated with an increase in maximum and minimum temperature. Change in precipitation pattern; the frequency and intensity of extreme events, such as heat waves and droughts, have a negative effect on cereal yield [32]. Climate change (temperature changes) would negatively affect rice production and positively influence rice price fluctuations in Indonesia [33]. Consequently, climate change threatens the agricultural sector and food security [34, 35]. The decline in rice production due to farm size reduction and climate change affects rice food security not only at the household level, but also at the national level.

Increasing rice production and productivity requires the continuous development and application of mechanization technologies such as farm machinery in rice cultivation. The improved agricultural technology adoption and dissemination impact household income [36]. The effect of farm mechanization on agricultural production and productivity is well known and reported [37], [38]. The impact of mechanization depends greatly on the degree of application of mechanization technology in fam practice. As a result, the current level of mechanization and crop yields is quite low in many developing countries and varies significantly between crops and regions within countries. The main reason for low productivity was found to be the lack of appropriate farm machines at the right time [39].

There are four levels of mechanization based on power source and human control, namely low, medium, high, and full mechanization [40]. Another method is based on power or energy availability, and its impact on agricultural productivity [41]. The technology levels are different between farms with different sizes [42]. In the study area, the mechanization level is developing slowly in quantity and type due to limitations such as small farm size, low household income, lack of repair and maintenance facilities, etc. [43]. Based on these conditions, the area's mechanization level can be classified as intermediate, where the work is done by a mechanical power source combined with a non-mechanical source and controlled by humans. Farm machinery in the Kampar region has recently adapted for labor-intensive activities including cultivation, harvesting/threshing, and milling [44]. Therefore, this study aims to investigate the rice food security status of smallholder farmers at the current level of mechanization in Kampar Regency, Indonesia. This research will reveal how farmers determine their rice consumption in a year and the minimum farm area required for households to meet food security at sufficient and safe levels. This research will provide important information on food security conditions at the household level and give farmers a solution to fulfill rice needs for them. Specifically, this research will benefit rice farmers who have small-scale farms to sustain their rice food security every year.

II. Materials And Methods

A. Description of Survey Area

This study used survey and observational methods to collect field data. Field research was conducted in April-June 2019 in two districts, Bangkinang and Kuok in Kampar. The districts are the most important rice production centers in the Kampar region and the use of farm machinery for rice operations is relatively higher than other districts in the region. The area's rice fields are mostly rain-fed and drying often takes place mainly during the dry season. This type of paddy field is very dependent on the climatic conditions of rice cultivation.

In the study areas, there are generally two seasons for rice cultivation, namely the rainy season (wet) and the dry season. The rainy season is the main rice growing season, with an area of up to 100% of the available rice field. The rainy season starts from September to March. The water supply in the rice field is sufficient for rice cultivation during the season, as the rainfall in 2020 is between 1,344 and 5,404 mm. The dry season from April to October is characterized by low rainfall. in the same year from 1,641 to 3,743 mm, so there is a lack of water in the rice field. Consequently, the entire rice field area cannot be planted during the season, so part of the area is cultivated with seasonal crops (palawija) such as corn, soybean, green beans, etc.

B. Sample Size

A total of 72 smallholder rice farmers were purposively collected as samples, consisting of 36 farmers from each selected area. Most of the samples are women who usually manage rice cultivation. Farmer samples are small-scale and used farm machinery on several farm operations. Most farmers use small farm machinery such as power tillers, irrigation pumps, combine harvesters or threshers, and rice milling units. They usually use machine hiring services managed by farmer groups in the vicinity.

C. Data Collection Technique and Analysis

The primary and secondary data used were collected from various sources. Primary data was collected by personally interviewing the sample farmers through semi-structured questionnaires (Figure 2).

Fig. 2 Survey team in the survey location together with rice farmers

The questionnaire was designed to collect primary data on the number of family members, farm size, rice production and productivity, and household rice consumption. Secondary data were collected from Food Crops, Horticulture and Plantation Services Department of Kampar Regency and Riau Province, Statistics Office and other related sources. The collected data were then tabulated and analyzed using a descriptive-quantitative approach and a simple regression technique.

III. Results and Discussion

A. Characteristics of Small Farmers

Most of the small farmers interviewed were women aged 28-29 and 5 years old on average. The age of household head is negatively associated with food security [45]. This is because women play a dominant role in the management of rice cultivation in the study areas. Their formal education varied from 2 to 12 years, with an average of 8 years. The educational level is a major factor associated with food insecurity [46]. Furthermore, the farmers had sufficient experience in rice cultivation up to 16 years on average, with a range of 2- 5 years. The number of members in the household varied from 2 to 8 people, with an average of 5 people. They can consist of father, mother, children and other family members who live together in the same house and share meals. The number of households affects the need for rice consumption and then on food security [47, 48]. This is because larger household members usually require more rice and much more family expenditure, mainly to buy various household needs.

B. Profile of Rice Farming

Most smallholders grow rice in a rain-fed field (Figure 2). There is no technical irrigation in the study area. The semi-technical irrigation system established by the government also dries up mainly during a long dry growing season. Therefore, the intensity of the rice cropping depends largely on the season. Generally, rice cultivation has two seasons viz. wet season and dry season. If there is rain throughout the year without droughts, rice can be grown twice a year. Under current climate conditions, there is great uncertainty about the intensity of rice cultivation. Rice cultivation is most common in the rainy season because there is sufficient water for cultivation until harvest. That is why local farmers call the rainy season the main season for rice cultivation. On the contrary, farmers always face some difficulties in rice cultivation during the dry season, mainly due to insufficient water supply in the rice field, which can reduce rice production and productivity. During the season, some farmers choose to grow soybeans, corn or green beans. We also found that few farmers did not grow rice in the dry season when the drought is severe.

In general, farmers engaged in subsistence farming with land area ranging from 0.11 – 1 ha with 0.37 ha on average. Most farmers (6%) divided the land which they owned into smaller plots, as shown in Figure 3. The number of plots varied between 2 and 30 plots, with an average of 13 plots owned. The size of the plots varies from farmer to farmer and varies from 150 to 500 m^2. In such conditions, the use of farm machinery can become difficult and limited, so the level of mechanization remains relatively low.

Fig. 3 Rain-fed paddy field in survey areas.

About 32 farmers rent land from other farmers to expand their cultivation areas, so some farmers can have 1 ha of cultivated area. However, none of the farmers in the study areas own one hectare of land. The rice field owned by the farmers is inherited from their parents or bought from other farmers. The sharing inheritance practice among local farmers led to land fragmentation and affected rice production and availability. Land fragmentation has been found to reduce farm efficiency by increasing production costs and reducing yield, income, profitability, and efficiency.

C. Mechanization Level

The main agricultural machines used for farm work in Kampar region are 4-wheel tractors, 2-wheel tractors, irrigation pumps, harvesters, threshers, and power threshers as shown in Figure 4. The largest farm machines in the study area are threshers, irrigation pumps, and 2-wheel tractors. They increased significantly during a period of 2010 and 2018. The smallest are 4-wheel tractors, which numbered only 12 units in 2018, compared to 1 unit in 2010. The number of rice milling units increased from 66 units in 2010 to 73 units in 2018, or an increase of 10% during the period. While the combine harvesters have been available since 2017 in the study area, and the machine number reached 19 units in 2018. In the future, the combine harvester will be more important because the machine can do both harvesting and threshing work at the same time and then save energy, time, and costs and reduce waste.

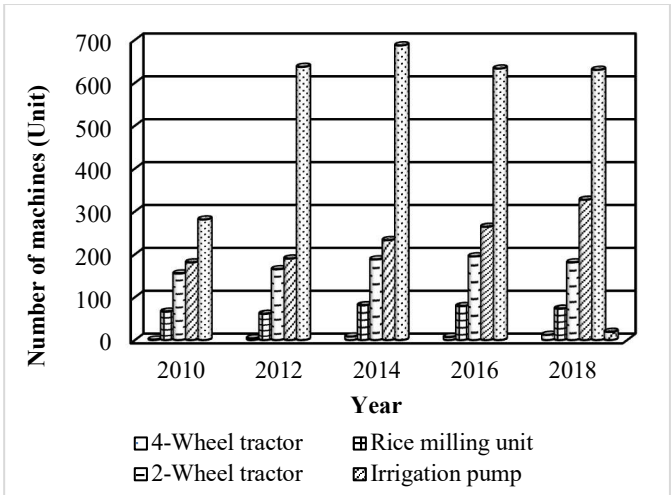

Fig. 4 The development of farm machines in Kampar Region during a period of 2010 - 2018 [49]

In addition, Figure 5 shows that the number of farm machines is still not sufficient for full mechanization. For example, a 2-wheel tractor needs at least 100 units per 1000 hectares to achieve full mechanization. The current number of farm machines was mostly less than 100 units per 1000 hectares, with an average of 36 units. Power thresher has only achieved more than 100 units per 1000 ha of paddy field area, accounting for 114 units. Therefore, according to Lantin [40], the current condition of mechanization remains at an intermediate level. In this situation, it is not easy to achieve maximum rice production and productivity because rice cultivation cannot be done entirely by mechanical power.

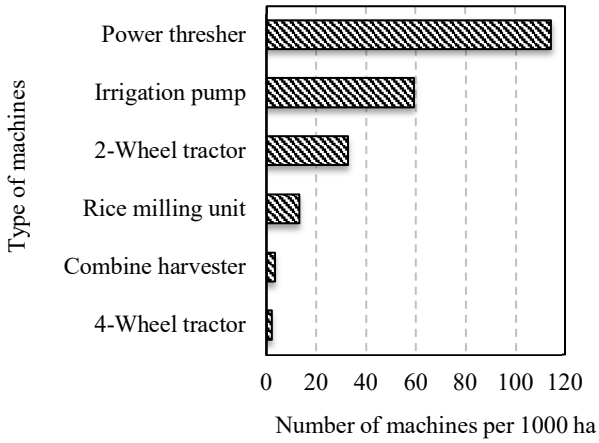

Fig. 5 Number of farm machines per 1000 ha of farm area

D. Rice Production, Productivity, and Farm Size

The rice production and productivity obtained by the farmers varied among them and were highly dependent on farm size, as shown in Figure 6. Rice production varied between 0.30 and .50 tons, averaging 1.33 tons. The production amount can reflect rice availability in the farmer households. Therefore, some farmers try to expand their farm size (cultivated area) by renting land from other farmers to produce much more rice to increase their household rice supply at least until the next harvest.

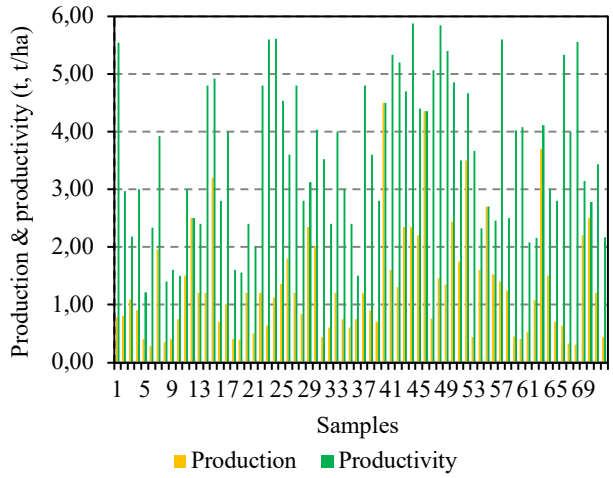

Fig. 6 Rice production and productivity in the study areas.

The rice productivity was also found to be low and varied widely among farmers from 1.21 to 5.88 tons.ha^{-1} and the average was 3.56 tons.ha^{-1} (Figure 6). The level of farm inputs

and mechanization technology applied on farming are important factors affecting rice productivity. Therefore, the level of mechanization must be increased by increasing the number and type of farm machines for each rice farm operation. Increasing the level of mechanization can then increase cropping intensity from once a year to twice or more a year. Fortunately, the availability of rice to farmers can double in a year.

Figure 7 shows the level of rice productivity for various farm sizes. The rice productivity level varied from 1,21 ton,ha^{-1} to 5.88 ton.ha^{-1}. The effect of farm size on productivity was not seen. The variation can be caused dominantly by different levels of technology application such as seeds, fertilizers, pesticides, and mechanization. The application of mechanization for land preparation (tillage) and post-harvest handling, for instance, may increase rice productivity. However, the larger farm size can usually make farm operation more efficient and the use of production inputs more effective. The smaller the size of the farm, the lower the costs for purchasing both production inputs and machine.

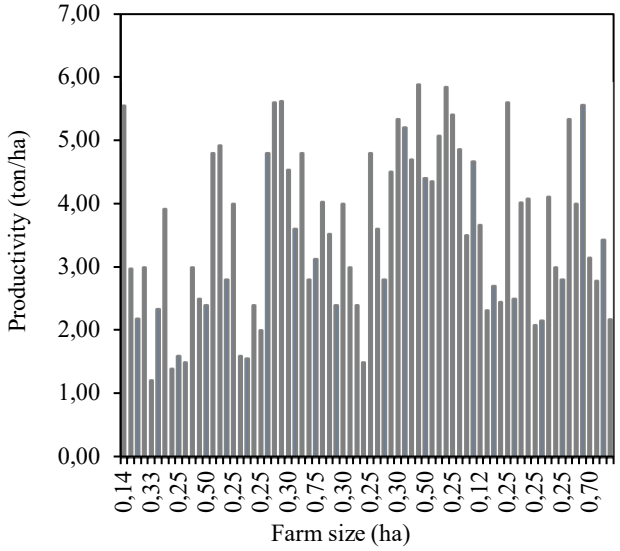

Fig. 7 Rice productivity levels for various farm sizes

E. Household rice consumption

Figure 8 shows that rice consumption in Indonesia has remained high over the past 10 years, ranging from 103 kg per capita per year in 2011 to 96 kg per capita in 2018, with an average of 98 kg per capita per year. Rice consumption did not decrease significantly during the period. Rice consumption decreased by only 7 kg per person per year, or 6% during the period. On the other hand, the average rice consumption per capita in the study area was higher than the national level, 114.6 kg.yr^{-1}. This is because the survey were conducted in rural areas where rice consumption is generally higher than in urban areas. Based on an average rice productivity of 3.56 tons.ha^{-1} with a milling recovery of 60%, it requires a farm size of 537 m^2 to cover the survey areas' annual per capita rice consumption. This means that a farmer's household with an average of 5 family members needs to cultivate about 0.27 hectares to meet the year's rice requirement for consumption.

It is common for Indonesians to eat rice as a main dish, usually served for breakfast, lunch, dinner and sometimes as a snack. Therefore, reducing Indonesia's rice consumption in a short period of time is very difficult. Rice has not only become a common food, but this food is easier to prepare, cook and find in the market at a low price compared to other foods such as corn, sweet potato, taro, etc. In the long term, it is necessary to gradually change consumption habits by diversifying food to reduce dependence on rice as a staple food significantly. Food diversification aims to increase basic food substitutes from local foods such as tubers, maize and sago found in the survey areas. In addition, the diversified production of both food and cash crops should also be encouraged to improve food security [50].

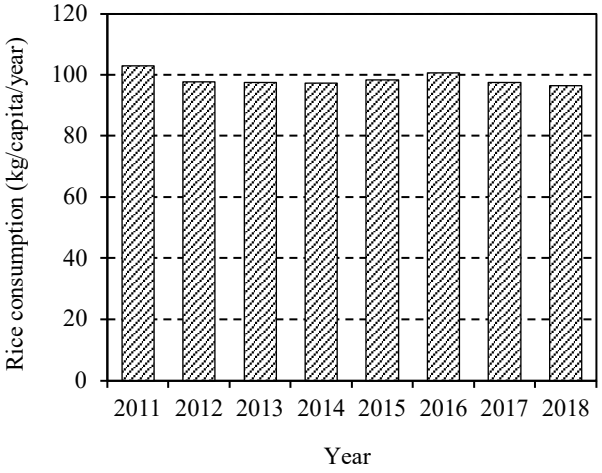

Fig. 8 Rice consumption in Indonesia during a period of 2011-2018

Smallholders usually plan to produce rice for home consumption throughout the year or towards the next harvest. They feel safe when there is always enough rice at home throughout the year. In interviews with farmers, it was revealed that the long-term supply of rice is difficult due to the low rice cultivation. Figure 10 shows that approximately 6% of small farmers could not meet the need for rice food during the year. They could supply rice for less than 12 months and up to 21% could supply less, up to 6 months (one growing season). This means that they are uncertain about the availability of rice for household needs and worries farmers about such a situation. Agricultural seasonality imposes significant fluctuations on food security [51]. Achieving food security requires farmers to integrate into income-generating activities to buy the food needed [52]. Generally, rice can be bought from local markets or convenience stores. At the same time, the remaining 54% of smallholder farmers could meet their household's rice food needs for up to 12 months. Small farmers whose production exceeds consumption sell it to the market to get additional income.

To solve the rice shortage problem and maintain food resilience, smallholders must increase rice productivity and/or cropping intensity twice a year, especially for those who can meet rice demand for less than a year [53]. The households with higher resilience capacity tend to have less child malnutrition and better food security. In addition, more intensive and versatile use of farm machinery in rice cultivation is the best way to increase both rice productivity and cropping intensity. From now on they will be able to satisfy the need for rice at a sufficient level every year and make the rice food security sustainable.

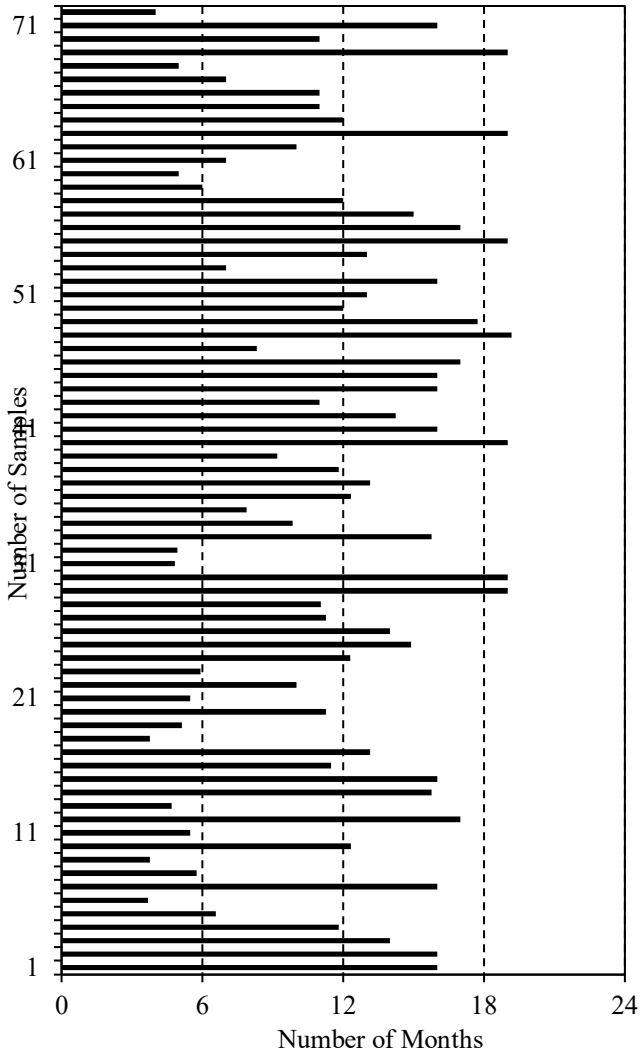

Fig. 9 Rice food security of small farmer households

IV. Conclusions

The current level of mechanization in the study area includes an intermediate category. In this category of mechanization level, the average rice production was found to be 1.33 tons on an average harvested area of 3.72 ha. Rice productivity was found to be low, with an average of 3.56 tons.ha^{-1}. It was observed that the rice productivity varied with various farm sizes. Per capita rice consumption was still high in the survey areas: about 114.6 kg.y^{-1} for members of a 5-person household. To satisfy the annual rice consumption per capita, it requires a farm size of 0.05 ha or 0.27 ha for the consumption of 5 household members. Thus, approximately 6% of small farmers could not cover rice's food requirement within one year. They could provide rice food for less than 12 months and even 21% of them could provide up to 6 months (one cropping season). The results suggest that mechanization should be increased by adding various machinery and a wide range of farms to improve rice production, productivity and harvesting intensity. In addition, smallholder farmers must change their consumption habits by diversifying their diet to reduce the dependence on rice consumption significantly. The findings further reveal how farmers determine their rice consumption in a year and the minimum farm area required for households to meet food security at sufficient and safe levels. This research provides important information on food security conditions at the household level and gives farmers a solution to fulfill rice needs for them. Specifically, this research will benefit rice farmers who have small-scale farms to sustain their rice food security every year.

Acknowledgments

The authors are grateful to the Riau Islamic University Pekanbaru for funding this research project. We are also obliged to Ceria Dona Legizasvera, Khairil Akbar, Hanafi Perdana Lubis, Gusrinazul, and Rizkika Wulamdari for their help collecting the data.

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