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# Production risks of mamar, a traditional agroforestry system in Timor Island, East Nusa Tenggara Province, Indonesia

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## Abstract

A traditional agroforestry named mamar has been commonly practiced by small-scale farmers of western part of Timor Island, East Nusa Tenggara Province. Mamar system is considered by many as an environmentally sound agriculture practice. However, as for other agriculture systems, the productivity of mamar system is also prone to risks caused by many internal and external factors. This study was designed to determine factors affecting the production and risk production of mamar. This research was conducted in four mamar-containing regencies of western Timor Island, East Nusa Tenggara Province. Eleven villages which have at least 30% mamar farmer households were selected from the regencies. From each village, 30 farmers were randomly selected and interviewed based on structured questionnaires. Multiple regression models ran with Eviews 6 software were utilized. Results showed that: land area, number of kinds of annual food, perennial cash, forestry, and fodder crops, number of animals reared, organic fertilizer usage, herbicide usage, number of labor days, quality of soil conservation significantly increased the production value, while slash and burn frequency reduced it; and number of annual crops, number of animal raised, amount of organic fertilizer, and number of labor days reduced farm risks. This indicates that mamar system complies with agriculture environmental soundness principles because it incorporates diverse crops; sound soil conservation nature; various number and kinds of animal raised which results in the provision of manure to mamar and other agro ecosystems; and the limitation of slash and burn. However, the use of inorganic herbicides needs to be controlled.

**Keywords**: Mamar, Agroforestry, Farm production risk, Indonesia, Timor

## Introduction

Agriculture product fluctuations resulted from uncertainty, often termed production risk, is usually unavoided by farmers (Kumbhakar and Tsionas 2009). The same condition is also applied to farmers of mamar farming system. Mamar is a traditional agroforestry system practiced by many small scale farmers of West Timor of East Nusa Tenggara Province of Indonesia. As suggested by Maydell (1987) and Jose and Gordon (2008), mamar is an agroforestry system which comprised of four main components namely annual crops, perennial woody crops, animal, and farmers. It is a mixed dry land garden incorporating annual food crops, perennial food, cash, forest, and fodder crops. The common crops are coconut, areca nut, betel, banana, and various local and introduced forest trees such as mahogany and teak, as well as fodder crops such as grass, leucaena, and sesbania. In the garden, there may or may not be a spring as the source of year round moisture for the crops. Mamar with a spring is normally called wet mamar and the one without a spring is termed dry mamar.

Several studies mentioned that organic agriculture is very common in developing countries and although considered as being subsistent, it represents an integrated farming system with integrated pest management system in it (Erhart and Hartl 2010; Jaradat 2015). This is also true for the traditional agroforestry mamar. Most farmers (75-85%) in mamar system do practice organic principles in their farming. Only about 10 to 25% farmers applied herbicides and inorganic fertilizers in mamar system. As an agroforestry system, mamar is also said to contain integrated pest, disease, and weed management (Dix et al.1999), to have a better water management than other farming systems (Riha and McIntyre 1999), to become a fodder source (Kapa 2007; Aggrey 1983). On top of all these multi-functions, mamar can also increase farmers' productivity and profit (Wu and Sardo 2010), and can minimize drought risks (Hutching 2009b) and margin risks (Hutching 2009a; Januartha, et al. 2012).

In other words, mamar agroforestry in Timor can function as a safety guard for the farmer's household through the provision of cash, food, fruits, fodder for animals, green manure, fire wood, and timber, as well as fire and wind break. The system can also absorb labor year round, whenever there is no farm activity in other agriculture systems. Despite all the above benefits, mamar system might also face risks due to the nature of the semi-arid climatic condition (Ellis 1988). Sambroek et al. (1982) mentioned that the degree of failure of such a system can be 25% to 75%. Semaoen (1992) stated that even though uncertainty of the outcome of a farming system is normally unknown, risks of outcome are predictable. However, both risk and uncertainty might result in a big loss or a big profit (Malcolm et al. 2005). Such risk in farming system is usually determined by price of commodity and market phenomena, as well as related technology and policy in input usage (Just and Pope 1979).

Ellis (1988) stated that farmers in the tropics normally face more severe uncertainty in their farming than farmers in temperate areas due to more unpredictable climate variability and the lack of market information obtained by farmers in the tropics than in the temperate areas. The latter condition resulted in the fact that farmers in the tropics act as price takers in that more often the price they have to take is in reality different from that it supposes to be. Therefore, this research was initiated to investigate the determining factors in mamar production value and production variance or production risk function in traditional agroforestry system, mamar, in Timor.

## Material and Methods

### Study location and sampling

This study was conducted in the western portion of Timor Island of East Nusa Tenggara Province of Indonesia. Four regencies, namely Kupang, South Central Timor, North Central Timor, and Malaka, were selected based on the abundance of mamar. Eleven villages with at least 30% of their farmers own a mamar were chosen from the selected regencies: two in Malaka, one in North Central Timor, two in South Central Timor, and six in Kupang. From each village, 30 farm households were randomly selected and interviewed. The interview was based on open ended and closed questionnaires.

### Data analysis

### Production function and production risk function

Risk analyses was performed based on Just and Poe (1978) production function modified by Kumbhakar (2002), Kumbhakar and Tsionas (2009; 2010), and Czekaj and Henningsen (2013). This model showed that inputs affect not just the outputs but also the output variations or the production risks as shown in the following.

$$y = f(X,Z) + U = f(X,Z) + h(X,Z)\varepsilon \quad (1)$$

where, y = output value; X = vector of summation of inputs ($X_1$, $X_2$, …$X_j$); Z = vector of summation of quasi fixed inputs ($Z_1$, $Z_2$, …$Z_k$); f(X,Z) = production function; hj(X,Z)$\varepsilon$ = production risk function (hj(X,Z) >0 denotes that an increase of input j would increase production risk; while hj(X,Z) <0 indicates that an increase of input j would reduce production risk); U= heteroscedastic error term with mean =0 and variance = $(h(.))^2$or $U^2$; $\varepsilon$= homoscedastic error term with mean =0 and variance ($\sigma^2$) =1.

There are two steps in estimating a production risk as suggested by Asche and Tveteräs (1999); Kumbhakar and Tveteräs (2003); first, estimating the average production function (f(.)) and second, calculating the absolute value of the residual of the production functions the dependent variable in estimating the production risk function (h.)). Here, the independent variable is the same as the independent variable of the production function.

Production and production risks function were estimated by using the normal logarithm of Cobb-Douglas production function and analyzed with ordinary least square (OLS). The determining factor for production function was expressed in the following equation.

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + \beta_{12} \ln X_{12} + \varepsilon_{1i} \quad (2)$$

Risks of production function was estimated by using the absolute value of the regression residue $|\varepsilon_{1i}|$ of the production function as follows.

$$|\varepsilon_{1i}| = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + \beta_{12} \ln X_{12} + \varepsilon_{2i} \quad (3)$$

where,

$\ln Y_i$ = Mamar production; calculated in production value (IDR.) and normalized by using the price of the dominant commodity; $\ln X_1$ = land area of mamar (ha); $\ln X_2$ = number of perennial crop kinds; $\ln X_3$ = number of annual crop kinds; $\ln X_4$ = number of animal (individuals); $\ln X_5$ = amount herbicide applied (liters); $\ln X_6$ = amount of inorganic fertilizer applied (kg); $\ln X_7$= amount of organic fertilizer applied (kg); $\ln X_8$= number of labor days.

$\ln X_9$= quality of soil conservation measures; $\ln X_{10}$= slash and burn frequency; $\beta_i$ = regression coefficient of i-*th* variable; $\varepsilon_{1i}$ =residue of production function; $|\varepsilon_{1i}|$=absolute value of residue of production function.

Decision criteria are as follows: $\partial|\varepsilon_{1i}|/\partial X_i<0$: if $X_i$ is increased the risk will be reduced and $\partial|\varepsilon_{1i}|/\partial X_i>0$: if Xi input is reduced the risk will be increased.

### Statistical analysis

All the statistical analysis was performed based on multiple regression models and ran with Eviews 6 software.

## Results

### Farm household profile

Mamar agroforestry is practiced by 30% to 50% of farm household of West Timor. The ownership of mamar is also related to the prestige of the farmer because it implies a high social status of the owner. Beside, this system also functions as a buffer for the household economy and the environment due to the various crops planted in the system. On average, the land area of mamar owned by farmers was 0.25 ha. Average number of kinds of perennial crops, annual crops, and animal raised were 11, 3, and 6. The average number of animal (mainly cattle and pig) owned was four per household. The cattle raising based on cut and carry system; the cattle would be stall fed in the sense that the cattle is tied in a den at or around the house or in the mamar and fed with cut and carry fodder. The fodder can be leucaena and sesbania leaves and twigs, local tree fodders, grass, agriculture wastes, and banana stems (as main source of fiber and water). Whereas for the pigs, the animals are denned and fed with corn, pumpkin, cassava leaves and tubers, papaya leaves and young fruits, banana stems, and even coconut flesh). These feed crops are grown in both mamar and non-mamar systems.

This study also revealed that even though in general mamar farming system is managed organically (relies heavily on natural fertility from the decomposed plant residues); however, in the last 2-4 years, about 17% of farm households applied inorganic fertilizers and 24% utilized herbicides. The average amount of inorganic fertilizer and herbicide usage were 1.28 kg $ha^{-1}$ and 0.82 l $ha^{-1}$, respectively. On the other hands, the average usage of organic fertilizer was 5.10 kg $ha^{-1}$ and was practiced by 35.15% of households. The usage of an organic and organic fertilizers are only occasionally done especially for annual crops cultivation in the mamar area as well as for nursery and early growth of perennials.

### Factors determining the production function and risks

Production function estimation revealed that there were 9 out of 10 factors studied proven to be significantly influencing the production function of mamar system; one of them was with significant negative regression coefficients and the remaining eight factors were with positive regression coefficients (Table 1). Factors with significant negative regression coefficient was slash and burn frequency with the regression coefficients of -0.046 ($p = 0.01$). At ceteris paribus situation, the additional one unit of slash and burn frequency, will result in a decrease of respectively 0.046 units of production of mamar system. Factors with significant positive regression coefficients were land area, number of perennial crops, number of annual crops, number of animal raised, amount of inorganic fertilizer, organic fertilizer, and amount of labor, soil conservation measure quality. However, if related to the production risk faced by farmers, only 4 of 9 the significant previous factors that were found to generate significant influence to reduce production risk. These factors were number of annual crops, number of animal raised, amount of organic fertilizer and amount of labor at probability level $p = 0.01$; $p = 0.05$ and $p = 0.1$.

Land area, number of perennial crop kind, number of annual crop kind, number of animal raised, amount of inorganic fertilizer, amount of organic fertilizer, amount of labor, and soil conservation measure quality were factors that significantly positively affecting the production of mamar with regression coefficients of 0.09 ($p = 0.1$); 0.14 ($p < 0.01$); 0.05 ($p < 0.05$); 0.03 ($p < 0.05$); 0.02 ($p < 0.05$); 0,20 ($p < 0.01$), 0,60 ($p < 0.01$), and 0.10 ($p < 0.01$), respectively.

Three of the above six factors that have positive significant influence on production can be further classified as biological diversity related factors and non-biological related factors. The biologically related factors were number of perennial crops, number of annual crops, and number of animal owned. The influence of these factors on the production risks was significant, except number of perennial crops.

The determination ($R^2$) coefficients of production value and production risk (Table 2) were 0.41 and 0.26, respectively.

## Discussion

The classical reasons for these agriculture chemicals besides to boost production, it is also related to the lack of labor (it is especially true for the use of herbicides). Even though slash and burn is uncommon for mamar system, in some cases such as if the population of plants is low, the available “barren land” would be cleaned and planted with food crops in a multiple cropping system. The preparation of land for this purpose would be done by slash and burn.

**Table 1. Estimation of production function and production risk function of Mamar by ordinary least square (OLS) approach.**

| Variable | Production function | | | Production risk function | | |
|---|---|---|---|---|---|---|
| | Coefficient | Error standard | t-Stat | Coefficient | Error standard | t-Stat |
| Intercept | 2.29*** | 0.26 | 8.76 | 0.38*** | 0.01 | 2.43 |
| $X_1$, Land area | 0.07* | 0.04 | 1.64 | 0.00 ns | 0.89 | 0.02 |
| $X_2$ Number of perennial crop | 0.15*** | 0.04 | 3.67 | 0.03 ns | 0.20 | 1.15 |
| $X_3$, Number of annual crop | 0.05** | 0.02 | 2.11 | -0.04* | 0.07 | -1.68 |
| $X_4$, Number of animal raised | 0.03** | 0.01 | 2.31 | -0.03*** | 0.01 | -2.25 |
| $X_5$, Amount of inorganic fertilizer | 0.01ns | 0.01 | 1.55 | -0.00 ns | 0.75 | -0.36 |
| $X_6$, Amount of inorganic herbicide | 0.02** | 0.01 | 2.15 | 0.00 ns | 0.61 | 0.52 |
| $X_7$, Amount of organic fertilizer | 0.02*** | 0.01 | 4.25 | -0.01* | 0.07 | -1.59 |
| $X_8$, Number of labor days | 0.60*** | 0.07 | 8.62 | -0.03*** | 0.00 | -9.66 |
| $X_9$, , Soil conservation measure quality | 0.10*** | 0.04 | 2.62 | -0.01 ns | 0.85 | -0.31 |
| $X_{10}$, Slah and burn frequency | -0.05*** | 0.01 | -3.33 | 0.03 ns | 0.79 | 0.33 |
| R-square | 0.41 | | | 0,26 | | |
| Adjusted R-square | 0.40 | | | 0.24 | | |
| Standard Error of regression | 0.32 | | | 0,18 | | |
| F-statistic | 22.57 | | | 11.27 | | |
| Probability (F-statistic) | 0.0000 | | | 0.0000 | | |

Notes: F Table at (10;318) and $p = 0.01$ is 2.34; $p = 0.05$ is 1.80; $p = 0.1$ is 1.62; t Table at (0.01);319 $\alpha = 1\%$ is 2.59; $\alpha = 5\%$ is 1.97; $\alpha = 10\%$ is 1.65. ***, **, * significant at $p = 0.01$; $p = 0.05$ and $p = 0.10$, respectively.

If this is done then, it will influence negatively the production of mamar. High temperature of burning and soil exposure to erosion might be the reason of the lower production trend of mamar under a slash and burn practice.

Number of perennial crops did not significantly generate production risks, but there is a trend of negative influence which means that an increase in number of plants will be followed by a decrease in the production risk. Higher regression coefficient of number of perennial crops than that of annual crops for production value indicates that perennial crops are more responsive to the production than that of annual crops. This is attributed to the fact that mamar system is dominated by perennial crops (including fodder, fruit, and timber crops) which consequently suppressed the presence of annual crops. The denser the perennial crops in mamar system, the less the presence of the annual crops.

The number of annual crops showed lower regression coefficient than that of perennial crops. However the annual crop displayed significant ($p=<0.10$) role in reducing production risk. It means that an incline in number of annual crops will be followed by a decline in the production risk as much as 0.035. This fact can be explained that in cases where productivities of perennial crops lessened due to old ages, the annual crops can be expected as substitute income generating, also when the perennial crops grew not thick, the annual crops could be planted in allay cropping systems. Furthermore, the annual crops could also grow in the edge of mamar, so they will receive abundance of light to help them grow.

The result also implied the fact that there is significant influence of animal owned by farmer on the production risk, the interaction between mamar and animal raising is obvious through the contribution of animal to provide barn manure to the mamar and vice versa the mamar system will provide fodder for the animals. As stated by Kapa (2007), in Amarasi area, mamar and animal raising especially stall fed cattle production are the main components of the integrated dry land farming system of West Timor.

The non-biological factors that positively affect the production were amount of inorganic herbicide, amount of organic fertilizer, amount of labor and quality of soil conservation measures. However, only amount of organic fertilizer and amount of labor that have the negative significant influence of the production risk. This indicates that with the increase of the amount of fertilizer and the amount of labor the production risk will decrease production risk by 0.01 and 0.03 respectively. The amount of organic fertilizer usage can still be increased. This is because results showed that despite the high percentage of animal possession by farmers (on average 92% of households possessed four animals per household) only about 45% of households have applied organic fertilizer to mamar crops with only 8.41 kg per household. Results also indicated that the amount of organic fertilizer usage significantly affected the production risk. This is in line with what was stated by Rahmawati (2017) that an increase of organic fertilizer would be followed by a decrease in production variation or production risks.

Results also showed that an increase in labor usage significantly affected the production value with a regression coefficient of 0.601 at $\alpha=1\%$. This indicates that an addition of a unit of family labor will increase the production value 0.601 units. Amount of labor ($X_8$) was found to be the most responsive input affecting production value of mamar. It can be explained that in small scale famers, when other production inputs were limited, labor displayed important roles in the farming process. As already mentioned before that amount of labor negatively significantly affected the production risk with a regression coefficient of 0.029 at $\alpha=1\%$. This indicates that an addition of a unit of family labor will decrease the production risk of 0.029 units. Rahmawati (2017) found also that labor negatively affected the production risk. However, on the contrary, Kumbhakar found a positive effect of labor toward the production risk.

Even though it is shown that there is a positive influence of labor on the production value of mamar system, age composition of the farmers might be a constraint for the maintenance of the mamar system. On average, the age of the farmers is considered relatively old (about 57 years). However, 17.6% of farmers were above the productive age limit (>64 years old), 33.3% were 51-64, and only 22.5% were below 40 years of age. On the other hand, average age of farmers in other farming systems is relatively younger (about 47 years) than that of in mamar systems, in which 7.6% of farmers were above the productive age limit (>64 years old), 31.2% were 51-64, and 30.9% were below 40 years of age. This means that mamar system is managed mostly by old aged and less of young aged farmers. This will in turn result in a rather neglected farming as compared to other farming systems (such as dry land food crop farming in the area. The reality that less young people involved in farming, such as in mamar system, does not indicate that there is less young people living in the area. The young people in the villages choose not to do farming but instead they choose to move out a living in informal sector. In this case, most young people in the villages choose to be motor cycle taxi drivers, shop attendants in cities, or mobile vendors in or around the village.

As stated by Maning (2011), agriculture in Indonesia is still the largest to provide employment for the people; however, this source of livelihood is not attractive enough for young people. There are at least two factors attributable to this. First factor is the limited access by young people to resources in the villages such as agriculture land. Second factor is related to the contents of elementary through high schools' curricula are not comprehensive enough to encourage pupil's interest to agriculture (White, 2012).

Table (1) also indicates that the quality of soil conservation measures significantly affects the production value. Even though, it did not influence the production risk significantly, but the regression coefficient showed a negative sign which means that an increase in the quality of the soil conservation measure should be followed a decrease in the production risk. Soil conservation measures should be a high quality because most of the mamar lands are hilly and mountainous with slopes above 30%.

The values of the determination coefficients for production function (0.40) and for the production risk function (0.26) were considered low. However according to Wooldrige (2005) stated that in social sciences especially those dealing with cross section data such as in this study, it is common to have such low coefficient of determination. This also does not mean that such results indicate poor models (Ghozali and Ratmono 2013). This is in line with what was mentioned by Greene (2003) that for cross section data, $R^2$of 0.5 and 0.2 are considered high and noteworthy. Another supportive opinion of the low $R^2$ values for social studies was by Walter et.al. (2004) who approved a very low $R^2$ of production risk of wheat, Kumbakhar (1999) also considers $R^2 = 0.09$ for production risk function as appropriate.

## Conclusions and Implications

The conclusions and implications of this study results are listed below:

1. Factors that significantly increase the production value of the traditional agroforestry mamar are land size, number of perennial crops, number of annual crops, number of animal raised, amount of inorganic herbicide applied, amount of organic fertilizer applied, labor days and quality of soil conservation measures. Factors that significantly decrease the mamar production is slash and burn frequency.
2. Land area and number of family labor did not significantly influence mamar production despite the fact that these factors are the main production factors of a farming system. It implies that action to be taken to increase mamar production should not be through the increase of number of land cultivated; instead, it should be done by increasing the intensity of land utilization. This can also be done through designing and applying programs in the villages to attract young people to be willing to work in agriculture sector.
3. Number of family labor is the only factor that significantly reduces the production risk; while the amount of herbicide applied is the only factor that increases significantly the production risk of mamar. The main reason for farmers to utilize inorganic herbicides is the lack of farm workers. Therefore, if more young people are interested to work in agriculture sector would also result in the minimization of production risk generated by the use of herbicides.

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