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DETERMINANT OF MAIZE FARMERS HOUSEHOLD FOOD SECURITY IN DRY LAND MADURA ISLAND, INDONESIA

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ABSTRACT

Food security must be ensured not only at the national and regional levels but also at the household level. The aims of this research were to examine the status and factors influencing food security among maize farmer households in the study area. A cross-sectional study was conducted between September and October 2023. A total of 151 households from two villages were chosen through a multi-stage sampling method. The household food security status was evaluated using the Household Dietary Diversity Score (HDDS). A binary logistic regression model was utilized to determine the factors influencing food security among maize farmer households. The study found that the majority (55%) of maize farmers experienced food insecurity, with an average HDDS of 7.23. The regression analysis indicated that household income, education level of the housewife, diversity of farm production, and cash transfers had a positive impact on food security. The findings imply that improving household income, promoting education (especially for housewives), encouraging diversified farming practices, and providing cash transfers are effective measures to enhance food security among maize farmers. These implications can guide policymakers and development practitioners in designing interventions to address food insecurity in agricultural communities. Enhancing the nutritional knowledge of housewives and promoting the cultivation of a greater variety of food plants in home gardens are recommended to improve household food security.

Keywords: *binary logistic, food security, food consumption, HDDS, Madura Island, maize farmer*

BACKGROUND

Hunger has plagued the world for centuries. Those affected by hunger experience a lack of calories and essential nutrients, rendering them too weak to carry out daily tasks such as work and schooling (Manurung et al., 2022). In 2022, the number of people suffering from chronic hunger increased, affecting approximately 9.2% of the global population. This figure is higher than the 7.9% recorded in 2019, before the COVID-19 pandemic (FAO et al., 2021). Meanwhile, Indonesia's hunger level is classified as moderate, ranking 77 out of 125 countries according to the Global Hunger Index 2023 (Global Hunger Index, 2023).

The situation is expected to deteriorate further if not urgently addressed. Population growth, particularly in developing countries, contributes to the increasing number of hungry people due to the rising global demand for food (Akinbode et al., 2022; Miladinov, 2023). Indonesia's population, for instance, has been increasing by an average of 3.152 million people per year since 1960 (World Bank, 2024). Simultaneously, global food demand is projected to rise by 35% to 56% between 2010 and 2050 (Van Dijk et al., 2021). However, the global food supply is threatened by climate change,

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evidenced by significant shifts in meteorological indicators such as rainfall, temperature, humidity, and wind speed (Chandio et al., 2020; Priyanto et al., 2023). Projections suggest that by 2030, changes in temperature and rainfall patterns could reduce the yields of key food commodities like rice, maize, and palm oil (World Bank Group, 2023). In response to these challenges, the United Nations has included ending hunger by 2030 as one of the Sustainable Development Goals, emphasizing the importance of achieving food security for all (United Nations, 2024).

Food security is a condition where everyone consistently has physical, social, and economic access to sufficient, safe, and nutritious food that meets their needs for active and healthy living (Peng & Berry, 2018). The agricultural sector plays a crucial role in achieving food security and food availability, particularly in agrarian countries (Wegren & Elvestad, 2018). Despite being recognized as a country heavily reliant on the agricultural sector to ensure the livelihood of its population, Indonesia still struggles to achieve food security (Moeis et al., 2020; Rozaki, 2021). While rice is the primary staple food, maize also plays a vital role in enhancing food security and income, especially in regions with high productivity potential (Grote et al., 2021; Mugisho et al., 2024; Akhtar et al., 2023).

Madura Island, located in the northeastern part of East Java, Indonesia, presents a unique case in the study of food security. The island is characterized by a dry land agroecosystem, with limestone mountains and non-volcanic soil that make it unsuitable for wet crop cultivation (Iswahyudi, 2022). Limited access to irrigation further exacerbates the challenges, leading to lower agricultural productivity and household incomes (Oni et al., 2011). These environmental and resource constraints make Madura particularly vulnerable to food insecurity, with recurrent droughts posing significant challenges to agricultural development and the livelihoods of local farmers (Hazell & Hess, 2010).

Maize is the most commonly cultivated crop on Madura, as the harsh conditions make rice farming less viable (Setiani et al., 2022a). However, maize farming in Madura is not without its challenges. The island's dry conditions, coupled with limited access to resources such as credit, technology, and market information, often compromise the food security of farming households. In this context, understanding the specific determinants of food security among maize farmers in Madura is crucial for developing targeted interventions that can enhance the resilience and sustainability of agricultural practices in dry land areas.

The Indonesian government's efforts to address food insecurity include programs such as Strengthening Public Access to Food in Food-Insecure Areas and Increasing Consumption of Vegetables, Fruits, Meat, and Animal Protein (Badan Ketahanan Pangan, 2020). However, these programs may not fully address the unique challenges faced by households in Madura, where food insecurity is influenced by factors such as household decision-making and the vulnerability of female farmers, who often earn less than Rp 500,000 per month and represent a significant portion of the food-insecure population (Samputra & Antriyandarti, 2024).

Previous studies have examined factors influencing household food security among farmers in various regions. For instance, research on smallholder farmers in Zimbabwe by Mango et al. (2014) identified variables such as the age and gender of the household head, household education level, household size, labor force, livestock wealth, and market information. Similarly, Zhou et al. (2019) explored the impact of distance from main roads, livestock ownership, access to credit and markets, food assistance, food prices, and disasters on rural households in northern Pakistan. However, research focusing on the specific context of dry land areas like Madura is limited. This study aims to fill this gap by identifying the factors influencing food security resilience among maize farmers on

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Madura Island. This following section of this article include the research methodology, findings and discussions, and conclusions and recommendations.

RESEARCH METHODS

This study was conducted on Madura Island in the East Java Province, Indonesia, which covers an area of 5025.3 km^2 and consists of four districts (Setiani et al., 2022c). First, Madura Island was chosen based on personal experience and information regarding the severity of food insecurity compared to other districts in East Java Province. Second, the Bangkalan and Sumenep districts were selected from four districts in consultation with regional experts due to their high potential for maize production. This selection also based on the positive correlation between maize production and food security (Danso-Abbeam et al., 2021). Third, the sub-districts of Galis in Bangkalan and Guluk-Guluk in Sumenep were chosen for the same reasons as in the second step. The final steps involved the random selection of villages within each sub-district, resulting in the choice of Peterongan village in Galis and Bragung village in Guluk-Guluk. With an initial sample of 160 women farmers, 151 were included in the final analysis. Women farmers were selected due to their responsibility for household food consumption preparation.

Measuring Maize Farmers Household Food security (MFHFS)

Most studies on food security employ various methods to measure it. In this paper, the Household Dietary Diversity Score (HDDS) serves as a proxy for household food security status. This proxy indicator, deemed attractive, represents the variety of food groups consumed within a given reference period (Ngema et al., 2018; Swindale & Bilinsky, 2006). The HDDS has found widespread use in numerous studies on dietary diversity and food security (Béné, 2020; Devereux & Tavener-Smith, 2019; Le et al., 2023; Mutea et al., 2019; Sekabira & Nalunga, 2020; Tanimonure et al., 2021; Vuong et al., 2023; Weigel et al., 2018).

A single 24-hour report of food recall data was applied (Huluka & Wondimagegnhu, 2019). The respondent was requested to list all the dishes, snacks, or other foods that were either consumed by household members at home or prepared at home (Dorado et al., 2017). The presence or absence of the food groups consumed then determined the HDDS (Mahmudiono et al., 2017). The identified food groups include cereals, tubers and roots, vegetables, fruits, meat, eggs, fish, nuts, milk and dairy products, honey and sugar, oils and fats, and various other foods (Ngure et al., 2021). The score ranges from 0 to 12, and the average is determined by dividing the sum of HDDS by the total number of maize farmer households. Because the HDDS is a continuous measure, it was computed to classify the Maize Farmer Household Food Security (MFHFS) as both food insecurity and food security (Niles et al., 2020).

Binary Logistic Regression Analysis

Logistic regression models are commonly employed to analyze the relationship between a binary outcome and a collection of covariates (Gosho et al., 2023). They provide a framework for estimating the likelihood of attaining food security (represented by a numeric value of 1) or experiencing food insecurity (represented by a numeric value of 0) within a maize farmer's household. The selection of determinants for the household's food security status was informed by several studies (Agidew & Singh, 2018; Ayele, 2020; Cheteni et al., 2020; Cordero-Ahiman et al., 2017; Hashmi et

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al., 2019; Kharisma & Abe, 2020). The description variables and their anticipated outcomes are outlined in Table 1, and the model is bellow:

$$MFHFS = \alpha_0 + \alpha_1 EDU + \alpha_2 INCOME + \alpha_3 LH + \alpha_4 MFHS + \alpha_5 FPD + \alpha_6 CRE + \alpha_7 CT + \alpha_8 AGE + \alpha_9 STATUS + U_t$$

Table 1. Description of Variables Utilized in The Binary Logistic Regression Model for Determining Factors Influencing MFHFS Status and Their Anticipated Outcomes

Variable	Description	Expected Sign
Dependent Variable		
MFHFS	Maize farmers household food security Food insecure=0; food secure=1	
Independent Variable		
EDU	Total years education: Not finished elementary school = 1 Elementary school = 6 years Junior high school = 9 years Senior high school =12 years University = 16 years	+
INCOME	Maise Farmer Household income in Indonesian Rupiah (IDR) per month (continuous)	+
LH	Land holding or farm size in hectares (continuous)	+
MFHS	The size of households of maize farmers; the count of individuals in each household (continuous).	(+/–)
FPD	Farm production diversity (FPD) refers to the total number of crops and livestock species cultivated and raised by households	+
CREDIT	Whether the household of maize farmers has access to credit is coded as follows: 1 = yes, 0 = no (categorical-dummy)	+
CT	Cash transfer: Whether the household of maize farmers has received government cash transfers was coded as a categorical dummy variable, where 1 indicates "yes" and 0 indicates "no."	+
AGE	Respondent's age in years (continuous)	–
STATUS	The marital status of the respondents was coded as follows: 1 for married and 0 for widowed, using a categorical-dummy coding scheme	+
$\alpha_0 - \alpha_9$	Coefficient	
U_t	error term	

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RESULT AND DISCUSSION

Maize Farmer Characteristics and Food Security Status

The food security status was determined by HDDS. Table 2 shows the frequency of food groups consumption, HDDS and food security status among maize farmers. All MFHs make rice a daily consumed food, resulting in the highest cereal consumption compared to other types of food (100%). This is in line with the findings of (Margareta & Purwidiani, 2014; Nurdin & Kartini, 2017). In addition, Madurese ethnic usually consumed mixed rice (maize and rice) due to the high production of maize in this area and their culture (Setiani et al., 2022c).

Types of food that are also highly consumed include oil (98.68%), vegetables (95.36%) and miscellaneous (85.43%). High oil consumption is prevalent due to the widespread practice of frying many types of food, particularly protein-rich side dishes. Additionally, snacks consumed between main meals, such as bananas, sweet potatoes, cassava, and various fried vegetables, also contribute to a high oil intake. Respondents indicated that they prefer the taste of fried foods over boiled or steamed alternatives. This finding is in line with previous research, which stated that the consumption behavior of fried food is more than once a day (Kurohman et al., 2020). Households consume a significant amount of vegetables due to their easy availability, either from their own gardens or purchased at relatively low prices. Moringa is the most commonly consumed vegetable, often harvested from their own yards or obtained from neighbors. Moringa is commonly found in home gardens and is widely consumed to meet the vegetable needs of the Madurese people (Andrias et al., 2019; Bahriyah et al., 2015; Setiani et al., 2022b).

The highest type of protein source comes from fish (78.15%), followed by nuts (52.32%), meat (35.76%), and eggs (31.79%). Fish is consumed more frequently due to its affordability and taste, particularly in comparison to meat. The most commonly consumed fish are mackerel tuna (tongkol) and Sardinella maderensis (pindang), which are highly popular in East Java, including Madura (Lelono & Bintoro, 2019). The high consumption of nuts is primarily in the form of tempeh and tofu, driven by their lower cost. Additionally, soybeans, the main ingredient in tempe and tofu, are considered functional foods rich in vegetable protein (Krisnawati, 2017).The consumption of tubers (20%) is dominated cassava and sweet potatoesFruit consumption is 44.37%, while milk is the least consumed food group (3%). Bananas and papayas are the most commonly consumed fruits due to their availability in home gardens or local markets at affordable prices. The low consumption of milk in Indonesia can be attributed to cultural factors and high prices (Juffrie et al., 2020; Valešová, 2017). Different from others country who consume milk as the culture and habits, In Indonesia is not common.

The average HDDS is (7.22±1.23), lower than prior study in Kenya (Aoko & Olang'o, 2021), but higher than study in south Nigeria (Tanimonure et al., 2021) and western Indonesia (Valešová et al., 2017). This study reveals that more than a half (55%) of the households were experienced in food insecurity in accordance with Widada & Mulyo (2017) who reported that food security status is lacking in over half of Indonesia. The high percentage of food insecurity caused by the low of dietary

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Table 2. Food Groups Consumption, HDDS and MFHFS Status

	Frequency	**Percentage**
Food Groups Consumption		
Cereals	151	100.00
Tubers and roots	31	20.53
Vegetables	144	95.36
Fruits	67	44.37
Meat	54	35.76
Eggs	48	31.79
Fish	118	78.15
Nuts	79	52.32
Milk and milk products	5	3.31
Oil/fats	149	98.68
Miscellaneous	129	85.43
HDDS		
4	2	1.3
5	11	7.3
6	30	19.9
7	41	27.2
8	44	29.1
9	22	14.6
10	1	0.7
Average (Std. Dev) = 7.22 (1.23)		
Food Security Status		
Food insecure	83	55,0
Food secure	68	45,0

Table 2 provides a detailed overview of the characteristics of maize farmers in relation to food security. Most of the respondents are graduates of elementary school (52.32%), while only 2.65% have graduated from university. The proportion of food insecurity status is dominated by respondents with low education, and vice versa. Therefore, improving educational attainment among maize farmers could be a critical step in enhancing food security. Moreover, both formal and informal education significantly influence women's empowerment and nutritional outcomes (Bhandari, 2017). Educational programs should focus not only on general education but also on agricultural techniques, resource management, and nutritional knowledge. Additionally, integrating nutrition education and women's empowerment programs can create a more holistic approach to addressing food insecurity.

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Table 3. Description of MFHFS and Characteristics

Variable	Food Insecure	Food Secure	Total	Mean (Std.Dev)	
Education				7,14	(3,42)
No school	9,27	2,6	11,92		
Elementary school	27,81	24,5	52,32		
Junior high school	10,60	6,6	17,22		
Senior high school	7,28	8,6	15,89		
University	0,00	2,6	2,65		
Income				5,57	(2,90)
< 5	33,11	17,22	50,33		
5 - 10	19,21	18,54	37,75		
> 10	2,65	9,27	11,92		
Land holding				0,30	(0,23)
< 0.5	45,03	29,80	74,83		
0.5 – 1	7,28	13,25	20,53		
1	2,65	1,99	4,64		
MFHS				5,77	(1,67)
≤ 4	13,91	8,61	22,52		
5 - 7	36,42	27,81	64,24		
≥ 8	4,64	8,61	13,25		
FPD				4,58	(1,75)
≤ 4	38,41	8,61	47,02		
5 - 7	14,57	30,46	45,03		
≥ 8	1,99	5,96	7,95		
Credit					
1 = yes	33,11	31,13	64,24		
0 = no	21,85	13,91	35,76		
Cash Transfer					
1 = yes	34,44	27,15	61,59		
0 = no	20,53	17,88	38,41		
Age				43.5	(11,74)
15 - 64	52,98	43,71	96,69		
> 64	1,99	1,32	3,31		
Status					
1 = married	48,34	40,40	88,74		
0 = Widow	6,62	4,64	11,26		

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Determinants of MFHFS

The results of the binary logistic regression are presented in Table 3. Based on the results, five variables were found to be significant determinants of the food security of landless households, which are explained below using odds ratios (ORs) (Table 3). The significant variables will be discussed more in the following section.

Table 4. Factors Influencing of MFHFS

	B	S.E.	WALD	SIG		ORs
EDU	0.151	0.068	4.897	0.027	**	1.163
INCOME	0.000	0.000	9.054	0.003	***	1.000
LH	1.303	0.938	1.928	0.165		3.679
MFHS	0.016	0.147	0.011	0.916		1.016
FPD	0.793	0.168	22.276	0.000	***	2.210
CREDIT	-0.907	0.498	3.314	0.069	*	0.404
CT	0.756	0.445	2.888	0.089	*	2.130
AGE	0.022	0.025	0.750	0.386		1.022
STATUS	0.006	0.763	0.000	0.994		1.006
Constant	-7.763	2.166	12.849	0.000		0.000

Significant at 10% *, 5% ** and 1% *** significance level.
Source: Survey Data (2023)

This study reveals that education has a positive and significant impact on MFHFS. Education provides farming households with access to the knowledge and skills necessary to implement more efficient and sustainable agricultural practices. Housewives with higher education levels are likely to contribute to the household's attainment of food security in the long term. Education plays a pivotal role in enhancing access to, production of, and utilization of food resources (Mutisya et al., 2016). In addition, farmers tend to be better able to understand appropriate agricultural technologies, utilize resources more effectively, and anticipate risks associated with environmental and market changes (Mango et al., 2014). The existence of low education levels is one of the primary factors responsible for poverty in rural households, which result in hunger and food insecurity (Nwokolo, 2015). The occurrence of force majeure events affects the food security of households with lower educational attainment more significantly than those with secondary or higher education, as rural households typically have lower levels of education (Arndt et al., 2020; Ningi et al., 2022).

Based on Table 3, most housewives in the study area were elementary school graduates, which impacted their understanding of proper food consumption patterns. Consequently, providing education or insights into food production and utilization, along with additional nutrition information, has been demonstrated to enhance food security among households and adults, particularly in rural areas (Eicher-Miller et al., 2020). The income variable shows that farmers' increased income affects their access to resources and services needed to improve food production and security. Food security is highly dependent on the extent to which the dryland resources available on the island of Madura can be utilized (Wijayanti, 2021). Households with large landholdings have better production (Adeniyi & Dinbabo, 2020), thus providing greater opportunities for these households to earn income to maintain food security (Mekonnen et al., 2021). Farmers with higher incomes tend to have

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improved accessibility to agricultural inputs (Adeniyi & Dinbabo, 2020). Therefore, increased crop and livestock production, changes in planting and harvesting dates, soil and water conservation practices, diversification of income sources as adjustment approach to improve household food security (Mekonnen et al., 2021). Positive income growth can provide food security (Yusuf, 2024) and benefit impoverished farming households, thereby contributing to sustainable development (Ogunniyi et al., 2021). This suggests that to increase farm income and food security, farmers need the support of increased farm inputs in order to obtain optimal production yields (Olounlade et al., 2020). Income can be increased by working in sectors beyond agriculture, such as craftsmanship, trading, selling produce from the yard, and other occupations. These activities can be undertaken not only by the head of the household but also by other family members. In addition, higher incomes enable farmers to access health and education services that are important for their family's well-being, which in turn can affect production and food security (Eicher-Miller et al., 2020). It is well recognized that farm production diversity (FPD) improves food security. This suggests that farmers engaged in diverse cultivation have greater opportunities for food security. Farm households can access a variety of nutrient supplies by cultivating various crops and livestock, which can more easily achieve food security (Rajendran et al., 2017). Diverse foods are easier to meet nutritional needs and avoid the thresholds set by international nutrition experts (Burchi & De Muro, 2016). Diversification of agricultural production can help increase natural enemies and reduce the number of pests, thus reducing the risk of crop failure (Jaworski et al., 2023). Production diversity can help mitigate the negative impacts of crop failure as it does not directly threaten family food security.

Additionally, farm households can have more consistent and diverse sources of income throughout the year by cultivating diverse crops and livestock (Rajendran et al., 2017). Some housewives in the study area commonly cook vegetables, particularly moringa, harvested from their home gardens to save money. Occasionally, they also sell fruits such as bananas, papayas, and mangoes at the nearest market to generate additional income. Lastly, in terms of long-term impacts, crop diversity supports sustainable farming practices and improves soil fertility (He et al., 2019; Lin, 2011). This is beneficial for future agricultural activities and maintaining household food security. Interestingly, farmers who have access to credit are more prone to experiencing food insecurity. We hypothesize that households are trapped in debt due to loans taken to purchase food, ultimately exacerbating their financial burden through interest, leading to increased vulnerability to financial difficulties (Kozlov, 2023). Moreover, the use of credit without proper financial planning can result in impulsive purchases, negatively impacting financial conditions (Fenton-O'Creevy et al., 2018). These households may not allocate funds for investments in resources or infrastructure that could enhance food security. Households lacking knowledge or skills in effective financial management may struggle to meet food needs (Carman & Zamarro, 2016). This cycle of poor financial decisions and escalating debt further exacerbates food insecurity, particularly in farming communities that depend on credit to meet their basic needs.

Cash transfers in Indonesia are promoted to reduce poverty and economic fragility within households (Dwiputri et al., 2023). This research demonstrates that food security is more likely to be attained by households that receive monetary transfers, and vice versa. The CT variable has an indirect effect on local economies (Ribas, 2020), influencing household savings, (Dwiputri, 2017), empowering poor and rural households to employ coping strategies, and increasing their food intake and general food security (Lawlor et al., 2019). Specifically, the provision of cash transfers, such as the BLT, has positive impacts on households' calorie and protein intakes per capita per day (Amrullah

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et al., 2020). This aligns with a study in Malaysia that reveals cash transfers can mitigate the impact of living expenses and enhance the overall quality of life (Nooh et al., 2021). However, since households allocate the additional funds towards other essential needs instead of food, the cash transfer from the village fund does not appear to significantly affect the change in household food consumption (Anisulfuad & Purwanti, 2023). This implies that while monetary transfers have advantages, their impact on food security is influenced by the prioritization of household expenditures. Consequently, a more targeted approach may be necessary to ensure that the intended nutritional benefits are fully realized.

CONCLUSION AND SUGGESTION

This study provides valuable insights into the state of household food security among maize farmers in the dryland areas of Madura Island. It unravels the complex dynamics of maize farming and its implications for household food security. Through an interdisciplinary lens, the study explores the intricate relationships between maize cultivation practices, socio-economic variables, and the overarching goal of achieving household food security. The findings highlight the necessity of targeted interventions that deal with the specific requirements and limitations faced by maize farmers on Madura Island.

Policymakers, agricultural practitioners, and development organizations should prioritize enhancing education and knowledge, particularly for women, as well as improving nutrition. This could be achieved through community-based extension services, and integrating agricultural education into local school curricula. Additionally, promoting farm production diversity through home garden utilization requires collaborative efforts among government agencies, non-governmental organizations, and local communities to ensure long-term food security for Madura Island. This could involve the distribution of seeds, tools, and training in sustainable gardening techniques, as well as establishing local cooperatives to facilitate the sharing of knowledge and resources.

As we navigate the complexities of agricultural development in this region, it is imperative to recognize the interdependence between maize cultivation, household food security, and broader socio-economic factors. Addressing these interlinkages holistically may help Madura's maize farming communities become more resilient, viable, and food-secure. This study serves as a stepping stone, inviting further research and policy discourse aimed at refining strategies and fostering inclusive growth in the agricultural development of Madura Island, Indonesia. Future research should continue to explore these interlinkages, providing deeper insights and refining strategies to support inclusive growth in the agricultural development and food security of Madura Island.

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