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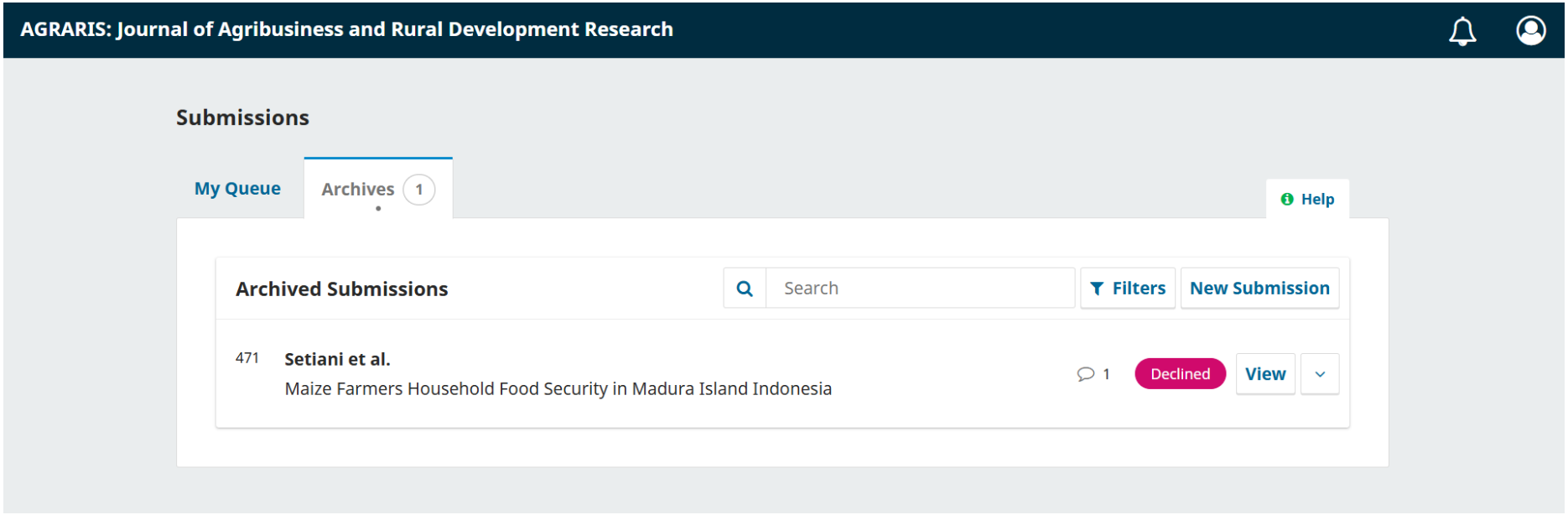

Journal Internasional 2 (Revisi Mayor – New Submission)

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The Impact of Farm Production Diversity on Household Dietary Diversity: Experience from Maize Farmers in Madura Island, Indonesia

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Running title: Farm Production and Dietary Diversity in Madura

The Impact of Farm Production Diversity on Household Dietary Diversity: Experience from Maize Farmers in Madura Island, Indonesia

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Novelty statement

This research affords a comprehensive insight into the relationships between household dietary diversity and production from farms among Madura Island's maize farmers. Utilizing an ordered logistic approach, the study uniquely highlights the role of diverse farm production practices in enhancing household nutrition. In contrast to previous studies that often focused on food security and broader agricultural contexts or specific crop impacts, this study provides a targeted analysis of maize farming households, offering valuable insights into how varying on-farm activities can directly influence dietary outcomes. The findings have significant implications for agricultural policy and food security strategies, specifically in similar rural areas.

Abstract

Farm production diversity (FPD) is closely linked to food security. Diversifying agricultural production not only provides a variety of food options for communities but also enhances the intake of essential nutrients. This study investigates the impact of farm production diversity on maize farmer household (MFH) dietary diversity. Employing questionnaires and in-depth interviews, the 24-hour meal recall method was used to gather information on 74 MFH consumption patterns. We applied the Household Dietary Diversity Score (HDDS) and ordinal logistic regression. All households (100%) consume both maize and rice as the source of cereals, whereas milk is the least consumed (1%). The majority of MFH (58.1%) are classified as medium, followed by high (35.14%), and the rest have low dietary diversity. MFH with higher levels of FPD have a greater likelihood of having high dietary diversity. Other significant factors affecting the HDDS were education, income, and government assistance.

Keywords: agriculture diversity; food security; HDDS; Madura Island; maize, ordinal logistic regression

Introduction

The Sustainable Development Goals (SDGs) number two aim to eradicate hunger and malnutrition, ensure food security, and promote sustainable agriculture by 2030 (Otekunrin & Otekunrin, 2021). Increasing food availability is simply one aspect of achieving food security; another is making sure that everyone has access to a variety of wholesome meals. Improved nutritional results and general health are closely correlated with dietary diversity, which is an essential aspect of food security. To address malnutrition and achieve food security, it is imperative to implement integrated strategies that include sustainable agricultural practices.

Agricultural diversification is a multifaceted strategy that enhances food security (Waha et al., 2022), improves nutrition (Douyon et al., 2022), increases resilience to climate change (Rautaray & Sucharita, 2024), and provides economic benefits (Rahmanto et al., 2021), making it a vital tool for sustainable development in developing countries. This approach is particularly relevant for regions such as Madura Island in Indonesia, where agriculture forms the backbone of the local economy and livelihoods.

Madura Island, located in East Java, Indonesia, is predominantly characterized by a strong focus on salt production (Fauziyah et al., 2023; Yaqin & Setiani, 2017) and corn (Fauziyah, 2020), with challenges related to resource utilization and productivity. Maize is a staple crop that supports the livelihoods of many farming households (Setiani et al., 2022a). However, there are a number of serious risks associated with relying solely on one crop, such as being susceptible to illnesses, pests, and changes in the market. More importantly, the population's health and well-being may be negatively impacted by nutritional inadequacies resulting from a diet that is mostly dependent on a single staple crop.

The household dietary diversity score (HDDS) is a key indicator of nutritional adequacy, which refers to the variety of foods consumed over a given reference period (Swindale & Bilinsky, 2006). Dietary diversity is strongly associated with improved nutritional status and health outcomes (Mamahit et al., 2024). In this context, farm

production diversity plays a crucial role in influencing the dietary diversity of households. Farming households can improve their nutritional intake by accessing a greater range of nutrients through the cultivation of diverse crops.

Research on food security and dietary diversity on Madura Island, particularly focusing on maize farmers, is limited. Previous studies have addressed various aspects of agriculture and food security in this region, including children's nutrition (Andrias et al., 2019); household food insecurity and stunting (Muslihah et al., 2022); dietary diversity and poverty (Oktaria et al., 2018); plant diversity in home gardens (Setiani et al., 2022b); and maize-peanut intercropping (Ali et al., 2019).

This study aims to address these gaps by identifying farm production diversity (FPD) in the study area and examining its effects on the dietary diversity of maize-farming households. Through this investigation, we seek to provide a comprehensive understanding of how diversifying farm production can enhance dietary diversity and contribute to food security among maize farmers on Madura Island.

Materials and Methods

Research location

This study is part of a larger research project on food security and stunting in Madura Island, funded by the Independent Research Grant from the Research and Community Service Institute of Trunojoyo Madura University (LPPM-UTM) in 2023. The selection of the research location was based on several considerations and carried out in two stages. First, Bangkalan Regency was chosen because it has both high poverty (Oktaria et al., 2018), and stunting rates (Muslihah et al., 2022) and is the second-largest maize producer on Madura Island (BPS-Indonesia Statistic Government Office, 2024). Second, Galis Subdistrict and Paterongan Village, as the largest maize producers, were selected based on recommendations from relevant agencies (the Department of Food Crop Agriculture and Horticulture, and the Agricultural Extension Center-BPP).

Determination of respondent samples

The number of sample determinations was guided by previous research using logistic regression analysis (Hu et al., 2021), which recommends a minimum sample size of ten times the number of independent variables. In this study, there are seven independent variables (Table 1); therefore, the minimum required sample size is 70. However, this study utilized 74 samples, exceeding the minimum requirement. The respondents were female maize farmers, selected using a purposive sampling method, as they possess better knowledge regarding household food consumption (Weigel et al., 2018).

Data collection

We collected data through surveys using questionnaires and in-depth interviews. Employing the 24-hour food recall approach, respondents were asked to recall every kind of food and drink they had consumed the day before (Khandoker et al., 2022; Otekunrin et al., 2023). The questionnaire included a series of questions regarding food consumed in the morning, afternoon, and evening, following the Household Dietary Diversity Score (HDDS) criteria (Kabir et al., 2022; Singh et al., 2023). Additionally, to bolster the arguments and justifications in this study, we also utilized secondary data from various institutions, such as the Department of Agriculture, Statistics Indonesia (BPS), and relevant academic journals.

Data analysis

Both the respondent characteristics and the MFH food consumption pattern were assessed using descriptive analysis. Twelve food groups were identified from the types of food consumed by MFH, and HDDS was used as an indication to quantify dietary diversity. A family received a value of "1" if they consumed a certain food group and a value of "0" if they did not. As a result, the number of food groups consumed was represented by the HDDS, which ranged from 0 to 12 (Yang et al., 2023). The results of the HDDS calculation were then used to determine the level of MFH dietary diversity in three categories: high if it is greater than 7, medium if it is between 6 and 7, and low if it is less than 5 (Chakona & Shackleton, 2018; Devereux & Tavener-Smith, 2019). We also calculate the average of HDDS by diveding total HDDS with the number of MFH.

The ordinal logistic regression analysis model was used to assess the impact of farm production diversity on the dietary diversity among MFH. Referring to Putri et al. (2022), the ordinal logistic regression model in this study is as follows:

$$Z_i = ln\left[\frac{P_i}{1-P_i}\right] = \alpha + \beta_1(\text{FPD}) + \beta_2 AGE + \beta_3 EDU + \beta_4 LH + \beta_5 INC + \beta_6 \text{HHS} + \beta_7 \text{DGA}$$

Where Z_i = probability of MFH, P_i = MFH probability determines the dietary diversity level when independent variables are known, α = intercept, $\beta_{1\text{-}7}$ = parameter coefficients. Table 1 displays the variables' descriptions in the model. The following are the study's hypotheses:

H_0 = there is no influence between independent variables and MFH dietary diversity.
H_1 = there is an influence between independent variables and MFH dietary diversity.

Tabel 1: Description of variable

Variables	Description	Exp Sign
Dependent Variable		
MFH dietary diversity (Z_i)	Dietary diversity level based on HDDS: 1 = Low 2 = Medium 3 = High (Yazdanpanah et al., 2021)	
Independent Variables		
- *FPD (Farm Production Diversity)*	The types of agricultural production generated by farmer households include food crops cultivated in the fields, food crops grown and utilized in home gardens, and livestock owned (Kabir et al., 2022; Sinyolo et al., 2021)	+
- *AGE (Age)*	Respondents' age in years.	+/-
- *EDU (Education)*	Total duration required for formal education:	+

	no schooling or not completed elementary schools = 1 elementary school = 6 years junior high school = 9 years senior high school = 12 years	
- *LH (Land holding)*	The agricultural land (fields) owned by farmers is measured in hectares.	+
- *INC (Income)*	Income is obtained from the total amount of revenue earned, measured in Indonesian rupiah (million IDR per month).	+
- *HHS (Household size)*	The number of household members is measured in individuals.	-
- *DGA (Dummy Government assistances)*	Government assistance (GA) to expand households' access to sufficient, safe, nutritious, and affordable food, such as direct cash assistance, and basic food needs. Dummy variable: not received = 0; received = 1.	+/-

Results And Discussion

Respondent characteristics

Table 2 summarizes the characteristics of the respondents. The majority of respondents (96%) are of productive age but have a low level of education, with 64% having only completed primary school. Regarding landholding, most maize farmers (85%) own small plots, typically around 0.5 hectares. Additionally, 42% of maize farmers have incomes ranging from $4 million to $8 million. The majority of households (58%) consist of 3 to 5 family members, with some households having up to 10 members.

Tabel 2. Respondent Characteristics

Variables		Quantity	(%)
Age (years old)	Productive (15-64)	71	96
	Non-productive (>64)	3	4
Education (years)	No Schooling	9	13
	Elementary School	47	64
	Junior High School	11	15
Land Holding (hectare)	Narrow (<0,5)	61	82
	Moderate (0,5-1 ha)	13	18
	Extensive (>1 ha)	0	0
Income (million IDR/month)	< 4	21	28
	4-8	30	41
	> 8	23	31
Household Size (people)	3-5	43	58
	6-7	22	30
	> 8	9	12
Ownership of livestock	Chicken	30	40
	Cow	8	11
	Goat	21	28
	Duck	6	8
Food plant utilization in Home Gardens	0 crops	17	23
	1-3 crops	46	62
	4-7 crops	11	15

The majority of people living in the study region are farmers, and the most common crops grown on the agricultural land are maize and peanuts. This result is in line with the findings of Nasih and Zakik (2019), who claimed that Madurese farmers grow food crops for their own subsistence. Because cultivation depends on rainfall, it is only done twice a year. Consequently, in addition to their primary emphasis on agriculture, maize farmers also use their free time for artistic pursuits like blacksmithing, which is usually done at night. In addition, some farmers raise animals and cultivate gardens in their homes.

Farm production diversity of MFH

The first source of FPD comes from the crops cultivated on the farm. Throughout the year, farmers primarily cultivate two types of crops (maize and peanuts) on their farm. The cultivation only occurs during the rainy season, while at the peak of the dry season, they leave their farm fallow. The majority of these farmers (68.91%) practice crop rotation (monoculture), while the remaining farmers employ intercropping methods. For the monoculture system, maize is planted from November to January, followed by peanuts, which are planted from February to April. They sell their crops to brokers or directly in traditional markets. Nasih and Zakik (2019) reported that Madurese farmers grow food crops for their own subsistence, which is consistent with the findings of this study.

The second source of FPD comes from the food crops cultivated and utilized in home gardens (Table 3). The diversity of food plants in these home gardens is predominantly fruit (61.11%), followed by vegetables (33.33%), with the remaining being tuber crops such as cassava. This finding aligns with Setiani et al. (2022b) who reported that fruits are more commonly planted than vegetables in traditional home gardens in Bangkalan. The most frequently utilized food plant is Moringa oleifera, which is used as a vegetable. This observation is supported by Wasonowati et al. (2020) who noted that Moringa grows in several locations on Madura Island. Other studies have indicated that Moringa positively impacts dietary diversity, nutritional status, and therapeutic outcomes (Gambo et al., 2022; Ndhlala & Tshabalala, 2023). The prevalence of Moringa in these studies suggests its potential to enhance dietary diversity and food security among MFH.

Table 3. Food plants utilize from home garden

No	Family	Scientific name	Name		N (%)	Utilization
			Common	Madurese		
1	Moringaceae	*Moringa oleifera*	Moringa	Marongghi	28	Vegetable
2	Anacardiace	*Mangifera indica*	Mango	Pao	18	Fruit
3	Aracaceae	*Cocos mucifera* L.	Coconut	Nyiur	11	Fruit
4	Solanaceae	*Capsicum frutescens*	Chili pepper	Cabbhi	8	Vegetable
5	Musaceae	*Musa paradisiaca*	Banana	Gheddeng	8	Fruit
6	Caricaceae	*Carica papaya*	Papaya	Kates	4	Fruit
7	Solanaceae	*Solanum lycopersicum* L.	Tomato	Tomat	4	Vegetable
8	Elaeocarpaceae	*Muntingia calabura L.*	Jamaica cherry	kersen baleci	3	Fruit
9	Myrtaceae	*Psidium guajava*	Guava	Jambhu	3	Fruit
10	Amaranteceae	*Amaranthus* spp.	Spinach	Tarnya'	3	Vegetable
11	Annonaceae	*Annona squamosa*	Custard Apple	Sarkaja	1	Fruit
12	Euphorbiaceae	*Manihot esculenta*	Cassava	Sabbhreng	1	Tubers
13	Lamiaceae	*Ocimum basilicum*	Basil	Komangi	1	Vegetable
14	Moraceae	*Artocarpus altilis*	Bread fruit	Sokon	1	Fruit
15	Punicaceae	*Punica granatum*	Pomegranate	Dhelima	1	Fruit
16	Rutaceae	*Citrus hystrix*	Lime	Jherruk porot	1	Fruit
17	Sapotaceae	*Manilkara zapota*	Sapodilla	Sabu	1	Fruit
18	Solanaceae	*Solanum melongena* L.	Eggplant	Terrong	1	Vegetable

The third source of farm production diversity (FPD) among maize-farming households (MFH) is the variety of livestock they raise. Chickens are the most commonly raised livestock, constituting 46% of the total, followed by goats (30%), cattle (13%), and ducks (11%). Many farmers diversify their livestock by raising multiple types, such as chickens and cattle, or a combination of chickens, ducks, and cattle. Chickens are particularly favored due to their ease of maintenance. Households consume eggs from both purchased sources and their own chickens. In contrast, goats and cattle are primarily raised to generate additional income, either sold directly in the market or through intermediaries. This finding aligns with Gitungwa et al. (2021) who reported that 18% of households in Tanzania raised chickens and used livestock as a means to generate funds.

Consumption pattern and dietary diversity

Cooking food once a day has become a common practice among MFH. Frequently, people eat the same food for lunch, dinner, and breakfast. In these homes, cereals are staples, especially rice and rice-corn mixtures. Grains like rice and maize are the main sources of food and calories in Southeast Asia, including Indonesia (Hafizah et al., 2020; Mohidem et al., 2022). In addition, maize serves as the staple food, which is typically consumed as a mixture of maize and rice (Al Yamini et al., 2023; Setiani et al., 2022c).

There is a high consumption of oil (97%) and vegetables (95%) among the population. The significant intake of oily foods is consistent with previous studies on fat consumption in Jakarta (Andarwulan et al., 2021). Conversely, the high vegetable

consumption can be attributed to their lower cost and greater availability. Moringa, in particular, is the most consumed vegetable, as it is readily available in home gardens and provides substantial nutritional benefits (Bahriyah et al., 2015; Setiani et al., 2022c).

Protein from both animal and plant sources should be considered alongside carbohydrates in dietary consumption. Fish and nut consumption as sources of protein reach 61%. Fish is a primary choice due to its affordability and palatability, with species like skipjack tuna and mackerel being particularly popular. Tofu and tempeh, which are made from nuts, are frequently selected for their high protein content and affordability, being cheaper than meat, fish, and eggs. The versatility and ease of preparing tofu and tempeh into various dishes contribute to their higher consumption compared to eggs (24%), meat, and poultry (45%). Households that raise chickens obtain a portion of their consumption (both meat and eggs) from their own production.

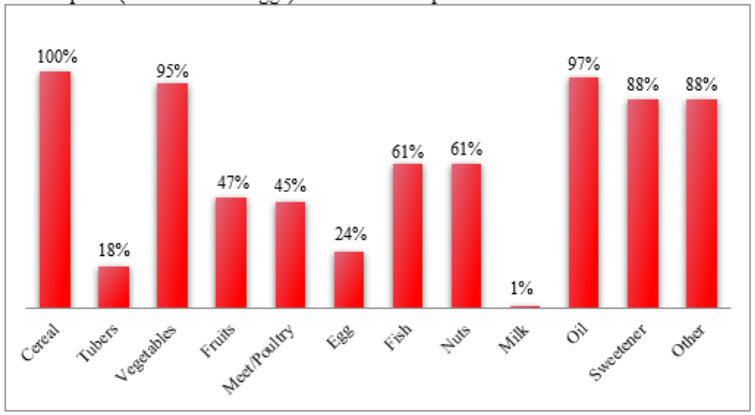

Figure 1. Percentage of Consumed Food Types (Processed Primary Data, 2023)

About 47% of farmer households consume fruits, most of which come from their own harvests. The majority of farmers grow various types of fruits in their gardens, with mangoes being the most commonly grown fruit, while others like bananas, papayas, and pomegranates are also cultivated. These findings support previous research results that indicating that utilizing home garden and diversifying household agricultural products by cultivating various crops, such as fruits and vegetables, can enhance self-sufficiency in food sources and serve as an alternative to improving household food security (Adjimoti & Kwadzo, 2018; Jateno et al., 2023; Nengovhela et al., 2022).

Less than a quarter (18%) of MFH consume tubers such as cassava, sweet potato, and taro, with some of these being harvested from their home gardens. The low consumption rate is attributed to the perception that tubers are inferior foods. Furthermore, this study reveals a very low milk consumption rate (1%), a problem also noted in Indonesia (Juffrie et al., 2020).

Table 4. HDDS of maize farmers household

Dietary Diversity level	HDDS	Number	(%)
High	> 8	26	35,14
Medium	6-7	43	58,11
Low	< 5	5	6,75
Total		74	100

As indicated in Table 4, the majority of maize farming households (58.11%) fall into the medium dietary diversity category. In addition, the average of HDDS is 7.1 This finding is greater than other study in Malaita (Bird et al., 2023) and Mexico (Vanessa Cordero-Ahiman et al., 2017) but lower than in Ecuador (Cordero-Ahiman et al., 2021).

The impact of FPD on the dietary diversity

This part of the article focuses on the impact of FPD and others factors on the MFH dietary diversity which applied the ordinal logistic regression (Table 5). The 2-log likelihood value is 128.023 with a significance level of p=0.000, indicating that the model with independent variables performs better than the model with dependent variables alone. It can be concluded that there is a fit between the models. The Pseudo R-square value of 0.304 indicates that the independent variables can explain 49.7% of the variation in the dependent variable, which is the z-score. The remaining variance is influenced by other factors not included in this study. Additionally, when the odds ratio value is >1, it indicates an increased likelihood of being in a higher category with each unit increase in the independent variable. Conversely, when the odds ratio value is <1, it signifies a decrease in the likelihood of being in a higher category with each unit increase in the independent variable.

Table 5. The ordinal regression output

Variables	Estimate	Odds Ratio (OR)	Std.Error	P value
FPD	0.611	1.841	0.212	0.004 *
AGE	0.020	1.020	0.027	0.447
EDU	0.210	1.233	0.106	0.047 **
LH	2.055	7.806	1.467	0.161
INCOME	3.891E-07	1,000	1.156E-07	0.001 *
HHS	-0.023	0.978	0.184	0.903
DGA	-1.421	0.242	0.603	0.018 **

Notte: * significant at $p < 0.01$; ** significant at $p < 0.05$

Farm Production Diversity (FPD) has an odds ratio (OR) value of 1.841 with a positive estimate, indicating that each unit increase in FPD is associated with a 1.841 times greater probability of achieving higher dietary diversity. This finding is supported by several studies conducted in different regions, including Bangladesh (Kabir et al., 2022), Uganda (Sekabira & Nalunga, 2020) and South Africa (Sinyolo et al., 2021). This study highlights the significant impact of FPD on dietary diversity in rural areas and dryland farming systems. By reducing market risks during periods of price volatility and production output variability—both of which are influenced by factors such as climate change—diversifying farm production ensures higher and more stable incomes.

As the education level of rural household heads increases, their awareness of the importance of consuming diversified food also rises. The odds ratio (OR) value of 1.233 for the education (EDU) variable indicates that each additional year of formal education increases the probability of achieving higher Household Dietary Diversity Scores (HDDS) by 1.233 times. This study supports previous research findings that education positively impacts dietary diversity and food security (Jateno et al., 2023; Sinyolo et al., 2021). Higher educational attainment can improve farmers' knowledge of effective farming practices, leading to better harvest yields. Consequently, this study suggests that increased education among female farmers enhances their knowledge, which ultimately improves dietary diversity among maize-farming households (MFH).

Higher household income enhances farmers' access to food, thus increasing their resilience to food dependency. This finding is consistent with Arslan et al. (2016), who found that household income has a positive coefficient, meaning that higher income for the head of the household increases the likelihood of the household being food secure and high dietary diversity. This is expected because increased income broadens access to food. Similarly, (2015) demonstrated that increased income positively affects food security by enhancing households' purchasing power to meet food needs. Farmer household income increases by selling crops and livestock such as peanuts, eggs, ducks, and chickens.

The number of family members and government assistance (GA) negatively impact the dietary diversity of maize farming households (MFH). The odds ratio (OR) value of -0.241 indicates that MFHs receiving GA are 0.241 times less likely to have a higher Household Dietary Diversity Score (HDDS). This finding suggests that GA recipients may misuse the assistance to purchase non-food items such as cigarettes, clothing, jewelry, and more. Consequently, food consumption by GA recipient households becomes more consumptive rather than nutritionally beneficial. These results are inconsistent with those of Amrullah et al. (2020), who found that providing assistance such as cash transfers has a significantly positive impact on recipient households in terms of energy provision, including calorie and protein consumption. Furthermore, it is noted that such assistance influences changes in food expenditure shares, resulting in shifts in food consumption from categories like tubers, animal products, fruits, and vegetables toward cereals, processed foods and beverages, and cigarettes.

Conclusion

Maize farmer households on Madura Island have diversified their farm production, including crops cultivated on their farms where maize is the primary crop, as well as in home gardens. They utilize their home gardens as an additional source of daily food by planting fruits and vegetables and raising livestock. The food consumption patterns of these farmers indicate diversity, with an average HDDS of 7.1, which includes cereals, vegetables, fruits, fish, legumes, and meat, though there is still a lack of tuber and milk consumption. The majority of these households (58.11%) fall into the moderate dietary diversity category.

Farm production diversity has a significantly positive impact on household dietary diversity, alongside factors such as female farmer (mother) education, income, and government assistance; however, government assistance alone has a negative impact.

The recommendations for farmers in the study area include enhancing the practice of utilizing home gardens for cultivating food crops such as vegetables, fruits, and other plants. Additionally, it is suggested that farmers use the land along the edges of their fields for growing vegetables like long beans or other varieties. Farmers should also consider raising animals such as chickens at affordable costs. These practices are expected to enhance farm production diversity and food security among farming households in the research location.

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