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IMPACT OF CLIMATE VARIABILITY IN THE SOCIOECONOMIC MODEL OF RICE FARMERS IN BANJAR REGENCY, INDONESIA

Ferrianta Yudi*, **Hamdani**
Department of Agribusiness, University of Lambung Mangkurat, Indonesia
*E-mail: ferrianta@gmail.com

ABSTRACT
Climate variability leads to changes in rainfall amount and patterns, resulting in shifts in the early planting season and planting periods. Floods in rice farming areas in several districts of Banjar Regency pose a risk of reduced agricultural production and income for farmers who solely rely on agriculture for their livelihoods. This can potentially lead to economic and food crises. This has an impact on the socio-economic behavior of farmers, both in *on-farm, off-farm, and non-farm* production systems, labor allocation, household consumption patterns, and it also affects food security, self-sufficiency, and the well-being of farmers. Based on the analysis results, there is a significant correlation between production behavior and consumption behavior through the income variable. Furthermore, consumption behavior (food consumption and health investment) influences production behavior. Household consumption behavior of farmers is determined by the availability of budget in the form of family income and family characteristics (the number of family members). In line with this, food consumption is greatly determined by income from sources other than rice farming, while investment expenditures, especially health investment, are largely influenced by the number of children. The influence of external factors in farming (climate variability, pests) greatly affects agricultural production and productivity, ultimately impacting farmers' behavior in determining their farming activities.

KEY WORDS
Socioeconomic model, climate variability, simultaneous regression.

Climate change refers to a modification in climate elements (precipitation, temperature, and humidity), whether caused directly or indirectly by human activities that alter the global atmospheric composition and also affect natural climate variability observed over a specific time period (UNFCCC 1992). Agriculture is one of the sectors most vulnerable to the impacts of climate change. Current agricultural development is confronted with various biophysical constraints and issues, including climate change caused by global warming due to the increased emissions of greenhouse gases (GHGs). Climate change has an impact on the changes in the physical and biological environmental systems, such as increased tropical storm intensity, shifts in precipitation patterns, seawater salinity, changes in wind patterns, animal and plant reproductive seasons, species distribution and population sizes, and the frequency of crop disease and pest outbreaks.

According to the outcomes of the *Intergovernmental Panel on Climate Change* (2014), this global climate change is highly sensitive to several aspects of human life systems, namely (1) water management and water resources; (2) agriculture and food security; (3) terrestrial and freshwater ecosystems; (4) coastal areas and oceans; (5) human health; and (6) settlements, energy, industry, and financial services. Climate change refers to a modification in climate, whether caused directly or indirectly by human activities that alter the global atmospheric composition and natural climate variability observed over a specific time period (UNFCC 2007). Changes in the climate system drive alterations in the frequency, intensity, spatial coverage, duration, and timing of extreme weather and climate events. Extreme events in weather or climate represent one facet of climate system variability, whether in stable conditions or during climate change (IPCC 2012). Climate change also leads to changes in air temperature and humidity, which can trigger the development and proliferation of crop pests and diseases.

All farmer households are required to implement strategies to sustain their livelihoods. However, only farmer households with assets and broad access are capable of sustaining their livelihoods. According to Mc Dowell and Hess (2012), the key assets for success are land and water (natural capital); labor, education, and health (human capital); social institutions (social capital); and financial capital. Therefore, the most important intervention that needs to be carried out is the establishment of social institutions (social capital) that can provide access to various livelihood assets for low-income farmer households. In addition to having livelihood strategies and access to resources, farmers also need timely access to climate forecasting information to maximize resource utilization. Timely and accurate climate predictions are considered essential components of farm management to provide effective strategies for maximizing food production and reducing agricultural losses due to climate variability.

Banjar Regency is mentioned as one of the areas most vulnerable to the impacts of climate change, particularly flooding, thus resulting in a high level of vulnerability and risk of rice production decline. Based on the data from the Department of Food Crops and Horticulture of Banjar Regency in 2020, the irrigated rice fields covered an area of 5,250 hectares, rainfed rice fields covered an area of 10,627.5 hectares, tidal swamp areas covered 31,721 hectares, and swampy lowland areas covered 8,380.5 hectares. The use of these rice fields is highly influenced by climate and rainfall. According to the preliminary data from the Department of Food Crops and Horticulture in 2020 (SIMTP data), rice cultivation covered an area of 84,800 hectares, with planting during the October to March planting season covering 47,439.5 hectares. The harvest from January to April 2020 covered an area of 9,648 hectares, producing 35,227 tons (Department of TPH Banjar, 2021). Meanwhile, the floods that occurred from February 26 to March 5, 2023, affected 11 districts, 99 villages/neighborhoods, inundated 17,360 houses with 21,076 households, and displaced 209 people (BPDP Banjar, 2023).

This will undoubtedly have an impact on farmer livelihoods, potentially resulting in a significant decrease in agricultural income and potentially affecting household consumption expenditure patterns, both in terms of food and non-food expenditures.

Based on the description provided, it is evident that climate variability in the context of farmers' livelihoods represents vulnerability. Therefore, it is necessary to develop a socioeconomic model for farmer households in addressing climate variability situations, which can be simulated in the form of adaptive responses capable of managing vulnerability

METHODS OF RESEARCH

The research location was intentionally determined for the Aluh Aluh district in the Banjar Regency. The selected agricultural area is one that produces wetland rice and is prone to flooding, with the research conducted from May to August 2023.

The formulation of this rice farmer household socioeconomic model is constructed using a simultaneous econometric approach. This is because in econometric approaches, there is an interaction between economic theory, observed data, and statistical methods, or in other words, it serves as a quantitative analysis of actual economic phenomena based on the development of theory and field observations (Verbeek, 2000; Gujarati, 1978; Intriligator et al., 1996; Thomas, 1997). Thus, the economic model of farmer households in this research is built based on both theory and empirical evidence in accordance with the research data.

The realities on the ground indicate that among the key issues, they mutually influence each other and are simultaneous in nature. Therefore, in analyzing this model, a simultaneous equation system approach is used by estimating a set of related equations, namely, production decisions, consumption, and labor allocation within farmer households.

The socioeconomic model of farmer households in this research consists of four blocks, namely: production block; labor input block; production cost and income block; expenditure block.

The equations constructed in each block have taken into account both theory and the field conditions indicated by the research data. The economic model of farmer households has undergone re-specification to accurately depict the on-field conditions based on the research data. The model is performed through simultaneous regression using the two-stage least squares (2SLS) method.

The economic model of rice farmer households requires a production function. Theoretically, the production function is assumed to be influenced by the use of variable inputs, fixed inputs, and the characteristics of farming. The rice production activity can be divided into two equations, namely the area equation (LATP) and rice productivity (YAPS).

Total cultivated land area:

$$LATP = a_0 + a_1 LAKS + a_2 PDTP + a_3 RISK + a_4 PDPNON + \mu_1 \quad (1)$$

Estimation parameter hypothesis: a_1 , a_2 , $a_4 > 0$; $a_3 < 0$

Where: LATP = Total cultivated land area (hectares); PDTP = Income from rice farming (IDR, thousand per season); RISK = Climate variability (index); PDPNON = Income from non-rice farming (IDR, thousand per season).

Productivity of rice farming:

$$YATP = b_0 + b_1 HG + b_2 RISK + b_3 LATP + b_4 YTKKS + \mu_2 \quad (2)$$

Estimation parameter hypothesis: b_1, b_2, $b^4 > 0$; $a_2 < 0$

Where: YAP = Rice farming productivity (tons per hectare); HG = Rice price (IDR per kg); LATP = Rice harvested area (hectares); YTKKS = Labor productivity (kg per HOK - Human Workday).

Rice production:

$$QTP = YATP * LATP \quad (3)$$

Where: QTKS = Total rice grain production (tons per planting season).

Labor Allocation of Farmers in Rice Cultivation Fields:

$$CTKSP = c_0 + c_1 LATP + c_2 CTKITP + c_3 CTKNON + c_4 UMTP + c_5 PUTP + \mu_3 \quad (4)$$

Estimation parameter hypothesis: c_1 , c_3 , $c_5 > 0$; c_2 , $c_4 < 0$

Where: CTKTP = Husband's labor input in rice farming (HOK/season); CTKNON = External labor input (HOK/season); CTKITP = Wife's labor input in rice farming (HOK/season); UMTP = Husband's age (farmer) (years); PUTP = Experience in farming (years).

Labor Contribution of Farmer's Wife:

$$CTKITP = d_0 + d_1 LATP + d_2 YATP + d_3 CTKTP + d_4 PUTP + \mu_4 \quad (5)$$

Estimation parameter hypothesis: d_1 , d_2 , $d_4 > 0$; $d_3 < 0$

Family Labor Input in Rice Farming:

$$CTKTP = CTKTP + CTKI \quad (6)$$

Labor Contribution of Farmers (Husband) outside of Rice Farming:

$$CTKLP = e_0 + e_1 LASTP + e_2 PUTP + e_3 PDDK + \mu_5 \quad (7)$$

Estimation parameter hypothesis: e_1 , e_2 , e_3 , $e_4 > 0$

Where: CTKLP = Labor input of farmers (husband) outside of rice farming (HOK/season); LASTP = Area of farming other than rice (ha); PDDK = Formal education of farmers (years).

Labor Contribution of Farmer's Wife outside of Rice Farming:

$$CTKILP = f_0 + f_1\ PDPTNUT + f_2\ UPAH + f_3\ LASTP + f_4\ PUTP + \mu_6 \quad (8)$$

Estimation parameter hypothesis: f_1 , f_3 , $f_4 > 0$; f_2 , < 0

Where: CTKILP = Labor input of the farmer's wife outside of rice farming (HOK/season); PDPTNUT = Income outside of rice farming (Rp000/season); UPAH = Labor cost for rice farming by the farmer (Rp000/HOK).

Total Labor Contribution of Farmer's Family outside of Rice Farming:

$$CTKLKS = CTKLP + CTKILP \quad (9)$$

Where: CTKLTS = total family labor input outside of rice farming (HOK/season).

Usage or Demand for Nitrogen Fertilizer Input:

$$QIPNTP = g_0 + g_1\ LATP + g_2\ PDTP + g_3\ PDPTNUT + g_4\ INVSKES + \mu_7 \quad (10)$$

Estimation parameter hypothesis: g_1, g_2, $g_3 > 0$; $g_4 < 0$

Where: QIPNTP= Usage of nitrogen fertilizer input (kg per season); INVSKES= Expenditure on health investment (IDR, thousand per year).

Usage or Demand for Phosphate Fertilizer Input:

$$QIPPTP = h_0 + h_1\ HIPP + h_2\ LATP + h_3\ PDTP + h_4\ INVESKES + \mu_8 \quad (11)$$

Estimation parameter hypothesis: h_2, $h_3 > 0$; h_1, $h_4 < 0$

Where: QIPPTP = Usage or Demand for Phosphate Fertilizer Input (kg per season); HIPP = Price of phosphate fertilizer input (IDR per kg).

Usage or Demand for Potassium Fertilizer Input:

$$QIPKTP = i_0 + i_1\ HIPK + i_2\ HG + i_3\ LATP + i_4\ PDTP + \mu_9 \quad (12)$$

Estimation parameter hypothesis: i_1, i_2, i_3, $i_4 > 0$

Where: QIPKTP = Usage or Demand for Potassium Fertilizer Input (kg per year); HIPK = Price of potassium fertilizer input (IDR per kg).

Usage or Demand for Pesticide Inputs:

$$QIPDTP = j_0 + j_1\ HIPD + j_2\ LATP + j_3\ PDTP + \mu_{10} \quad (13)$$

Estimation parameter hypothesis: j_2, $j_3 > 0$; $j_1 < 0$

Where: QIPDTP = Pesticide input usage or demand (liters per season); HIPD = Pesticide input price (IDR per liter).

Expenditure on food consumption:

$$KONSPG = k_0 + k_1\ JAK + k_2\ PDT + k_3\ PDPTNUT + \mu_{11} \quad (14)$$

Estimation parameter hypothesis: k_1, k_2, $k_3 > 0$

Where: KONSPG = Food consumption (kg per capita); JAK = Number of family members in the farmer's household (individuals).

Expenditure on Education Investment:

$$INVSPND = l_0 + l_1\ PDPTNUT + l_2\ PDPTT + l_3\ INVSPROD + \mu_{12} \quad (15)$$

Estimation parameter hypothesis: l_1, $l_2 > 0$; $l_3 < 0$

Where: INVSPND = Expenditure on education investment (IDR, thousand per season); INVSPRD = Expenditure for the next farming investment (IDR, thousand per season); PDPTT = Income from livestock farming (IDR, thousand per season).

Expenditure on Health Investment:

$$INVSKES = m_0 + m_1 JAK + m_2 JAS + m_3 INVSPND + m_4 PDPTT + \mu_{13} \quad (16)$$

Estimation parameter hypothesis: m_1, m_2, $m_4 > 0$; $m_3 < 0$

Where: INVSKES = Expenditure on health investment (IDR, thousand per year); JAS = Number of school-going children (individuals).

RESULTS AND DISCUSSION

Rice production behavior is structured into two behavioral equations: crop planting area and rice productivity.

Table 1 – Parameter estimation and elasticity of production behavior equation for rice farmer households in 2023

Dependent Variable: Crop planting area.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Owned land area	1	8.555091	0.242363	35.30	<.0001
Income from rice farming	1	1.03E-8	3.044E-9	3.38	0.0009
Climate variability	1	-0.26379	0.055761	-4.73	<.0001
Income from non-rice farming	1	0.299235	0.057183	5.23	<.0001

Dependent Variable: Productivity.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Rice price	1	0.006713	0.000216	31.02	<.0001
Climate variability	1	-0.014121	0.003792	-3.72	-0.0003
Harvested area	1	2.639816	0.249704	10.57	<.0001
Labor productivity	1	0.010264	0.026343	0.39	0.6974

All parameter estimates in the planting area equation significantly differ at the 1% significance level. Positive parameter estimate values indicate that changes in the explanatory variables are in the same direction as changes in the planting area. As land ownership area, income from rice farming, and non-farming income increase, the planting area also increases. The negative value of climate variability implies that an increase in production risk due to climate variability leads to a decrease in changes in the rice planting area – (climate variability is proxied by production risk, in this research using the *variance of production error.* One of the models to accommodate this is the GARCH (1,1) model, where p = 1 and q = 1. Production risk is obtained by estimating the production function and the variance of error. The production function used is the Cobb Douglas production function in natural logarithm form. The specific commodity analyzed is the dominant commodity cultivated by farmer households).

All parameter estimate signs in the productivity behavior function of rice farming are in accordance with expectations or economic criteria. Positive parameter estimate signs signify that changes in the explanatory variables are in the same direction as changes in rice farming productivity behavior, meaning that higher rice prices, harvest area, and labor productivity in the farming area result in higher productivity. Conversely, the same applies to climate variability variables; an increase in production risk, such as floods, will decrease productivity.

The labor allocation behavior of rice farmer households is structured into four behavioral equations. These behavioral equations encompass labor allocation by the husband, by the wife, and labor allocation by the husband and the wife outside of rice farming.

Table 2 – Parameter estimation and elasticity of labor allocation equation for household members of rice farmers in 2023

Dependent Variable: Family labor force (husband).

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Rice planting area	1	0.096853	0.010059	9.63	<.0001
Labor by wife	1	-0.25884	0.078216	-3.31	0.0012
Non-family labor	1	0.004444	0.003049	1.46	0.1471
Farmer's age	1	-2.14574	3.083768	-0.70	0.4877
Farmer's experience	1	2.321362	0.335996	6.91	<.0001

Dependent Variable: Labor by wife.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Rice planting area	1	0.666970	0.098458	6.77	<.0001
Productivity	1	4.536561	1.130337	4.01	<.0001
Labor by husband	1	-0.65282	0.944163	-0.69	0.4904
Farmer's experience	1	2.246910	6.791817	0.33	0.7413

Dependent Variable: Labor allocation of husbands outside of rice farming.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Land area for non-rice farming	1	0.300783	0.090936	3.31	0.0012
Farmer's experience	1	2.388565	0.414719	5.76	<.0001
Formal education of farmers	1	0.337363	0.106886	3.16	0.0019

Dependent Variable Labor allocation of wives outside of rice farming.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Income outside of rice farming	1	0.021003	0.003984	5.27	<.0001
Labor costs in rice farming	1	-1.89661	0.369851	-5.13	<.0001
Area of farming other than rice	1	0.604545	0.035768	16.90	<.0001
Farmer's experience	1	2.363568	0.248892	9.50	<.0001

The labor allocation of husbands and wives is primarily determined by farming characteristics, namely, land area and productivity, labor availability, the age of the husband, and farming experience. Most of the explanatory variables in the behavior of labor allocation of husbands outside of rice farming differ significantly from zero at a 1% significance level. In line with this, farming experience significantly influences the labor allocation of husbands outside of rice farming. The wife's labor variable has a negative value, indicating it serves as a substitution factor for the husband's labor. Meanwhile, age implies that as farmers grow older, their performance in allocating their labor to farming activities decreases.

The labor allocation behavior of wives outside of rice farming reveals that the decision of farmers' wives to invest their time outside of rice farming is driven by the intention to economize labor costs within rice farming and as a substitution for their husband's labor. The individual characteristics of wives, such as their farming experience, determine the extent of their labor allocation outside of rice farming because job opportunities, especially outside of farming, are more accessible to wives with specific skills and expertise.

Off-farm labor allocation, particularly in horticulture, is significantly influenced by the extent of land cultivated outside of rice farming, as well as the income derived from those agricultural activities. Additionally, farmers' experience and education, particularly in farm management, play a role. Labor costs also have a substantial impact on labor allocation, as when labor wages in rice farming increase, farmers tend to reduce their labor allocation outside of rice farming, which is their primary crop.

The input usage and household income of plasma farmers are organized into four behavioral equations. These behavioral equations encompass the usage of nitrogen fertilizer, phosphate fertilizer, potassium fertilizer, and pesticide usage.

The price variable has a negative sign, indicating that an increase in fertilizer prices will reduce fertilizer usage. However, on the other hand, land area and total income have a positive impact on fertilizer usage. Fertilizer usage will increase if the rice price increases, even though the response of fertilizer usage to changes in rice price is low. The negative value of the health investment expenditure variable reflects that this variable has an opposite direction to the fertilizer usage variable. Fertilizer costs compete with household expenditures in the allocation of farmer household budgets.

Table 3 – Parameter Estimation and Elasticities of Input Usage Behavior Equation in Rice Farming for 2023

Dependent Variable: Usage of nitrogen fertilizer.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Farm land area	1	1.231833	0.432350	2.85	0.0050
Income from rice farming	1	4.152524	0.505830	8.21	<.0001
Income from non-rice farming	1	9.510331	0.341967	27.81	<.0001
Health investment	1	-3.29965	0.618592	-5.33	<.0001

Dependent Variable: Usage of phosphate fertilizer.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Phosphate fertilizer price	1	-1.26741	0.670889	-1.89	0.0609
Rice planting area	1	0.029628	0.005177	5.72	<.0001
Income from rice farming	1	0.020989	0.004509	4.65	<.0001
Health investment	1	-0.00750	0.007257	-1.03	0.3028

Dependent Variable: Usage of potassium fertilizer.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Potassium fertilizer price	1	-5.68264	0.621249	-9.15	<.0001
Rice price	1	0.000276	0.000093	2.95	0.0037
Rice planting area	1	0.031337	0.011301	2.77	0.0063
Income from rice farming	1	0.100134	0.000550	182.21	<.0001

Dependent Variable: Pesticide usage.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Pesticide price	1	-2.13666	0.722458	-2.96	0.0036
Farm land area	1	0.428312	0.075898	5.64	<.0001
Income from rice farming	1	0.199934	0.074843	2.67	0.0084

The response of pesticide usage to nearly all variables related to farm land area is positive. This implies that if farmers increase their land area, the amount of pesticide usage will also increase. Farm income also influences pesticide input, as higher income from rice farming provides farmers with more flexibility to manage their agricultural operations, especially in allocating funds for pesticide inputs.

The expenditure behavior of rice farmer households consists of three behavioral equations, namely expenditure equations for food consumption, education investment, and health savings.

Table 4 – Parameter Estimation and Elasticities of Expenditure Behavior Equation for the Year 2023

Dependent Variable: Food consumption of farmer families.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Number of family members	1	27.30387	3.486537	7.83	<.0001
Income from rice farming	1	9.61E-10	5.09E-10	1.89	0.0609
Income from non-rice farming	1	0.123880	0.043741	2.83	0.0053

Dependent Variable: Farmers' education investment.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Income from non-rice farming	1	0.682003	0.084993	8.02	<.0001
Income from livestock farming	1	0.058106	0.009282	6.26	<.0001
Investment in farming	1	-6.45768	0.893694	-7.23	<.0001

Table 4 Continue. Dependent Variable: Health investment.

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Number of family members	1	36.00246	6.383634	5.64	<.0001
Number of school-going children	1	60.90077	5.854898	10.40	<.0001
Education investment	1	-0.29719	0.079705	-3.73	0.0003
Income from livestock farming	1	0.026523	0.007886	3.36	0.0010

The estimation results indicate that all signs of parameter estimates have met expectations or economic criteria. The statistical criteria show that the majority of estimated parameters are significantly different from zero at a significance level of less than 10%, especially household characteristic variables such as the number of family members, the number of school-going children, and the total number of family members. Overall, several explanatory variables significantly influence at the 10% level, namely income from rice farming, income from non-rice/horticulture farming, and income from livestock farming.

All variables significantly influence the equation for education investment expenditures, such as income from rice farming, income from non-rice farming, and livestock income. However, production investment has a negative sign, indicating that as production expenditure increases, savings for education decrease. The expenditure behavior for health savings is highly influenced by the number of family members, the number of children and toddlers, and income from livestock farming. The negative sign of school expenses or education costs reflects that this variable substitutes with health investment/savings.

CONCLUSION

The economic behavior of farmer households in all activities (production, labor allocation, and expenditures) has met the expected economic criteria. Estimation results indicate a significant relationship between production behavior and consumption behavior through the income variable. Furthermore, consumption behavior (food consumption and health investment) influences production behavior (the use of fertilizer and pesticides).

Household consumption behavior of farmers is determined by the availability of a budget in the form of total family income and family characteristics (the number of family members). Meanwhile, investment expenditures, especially in healthcare, are greatly influenced by the number of family members and the presence of school-going children.

The climate variability variable has a negative impact on the production equation and productivity. This indicates that production risk, specifically climate variability, will decrease rice production and productivity, ultimately affecting the socio-economic behavior of households.

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