What Happens to Rainfed Corn Farmers on Climate Change? Overview of Income and Technical Efficiency at East Java

Mardiyah Hayati[1*], Mohammad Wahyu Firdaus[2], Taufik Rizal Dwi Adi Nugroho[3], Syafrial[4], Fatahullah[5], Mohammad Wildanul Jannah[6]

{mardiyah@trunojoyo.ac.id [1], mwahyufirdaus@student.ub.ac.id [2], taufikrizal@trunojoyo.ac.id [3], syafrial.fp@ub.ac.id [4], fatahullah17@student.ub.ac.id [5], wildan96@student.ub.ac.id [6]}

Program study of Agribusiness, Agricultural Science and Technology Department, Faculty of Agriculture, Trunojoyo Madura University, Bangkalan, Indonesia[1,3]
Program study Master of Agriculture Economics, Socio-economics Department, Faculty of Agriculture, Brawijaya University, Malang, Indonesia[2,5]
Socio-economics Departement, Faculty of Agriculture, Brawijaya University, Malang, Indonesia[4]
Program Study Master of Aquaculture, Fisheries and Marine Resources Management Departement, Faculty of Fisheries and Marine Science, Brawijaya University, Malang, Indonesia[6]

*Corresponding Author

Abstract. Climate change conditions due to long droughts have forced farmers in East Java to adapt, especially due to limited water supplies. The research evaluates production results, considering farmers' income levels and technical efficiency under climate change conditions. We used a multistage sampling method to determine research locations, and 70 dryland and rainfed corn farmers were selected purposively. As a result, the current level of farmer income is around IDR 9,175,972 per hectare, lower than other regions in similar conditions. The Cobb-Douglass frontier function shows that seed input, fertilizer, and land area significantly influence production. Furthermore, the level of technical efficiency is 82.9%, indicating that agricultural practices still need to be more efficient in climate change conditions. This research also highlights that farmers' social activities in groups and the role of stakeholders as instructor are key variables in increasing farmers' knowledge regarding adaptation strategies in facing climate change.

Keywords: Climate Change; Corn Farmers; Rainfed; Technical Efficiency

1 Introduction

Agriculture has historically played an essential role in improving the livelihoods of poor people, especially in developed countries, and remains a crucial sector in developing countries [1]. However, the vital role of the agricultural sector is currently being confronted by a big challenge, namely climate change [2]. Climate change has hurt all economic activities, especially in the agricultural sector, and has become a global environmental threat [2], [3]. Climatic factors are characterized by rainfall, increases in minimum and maximum temperatures, flood fluctuations, drought and other weather factors [4]; [5]. Most studies have

RESILIENCE 2023, November 24, Jakarta, Indonesia

DOI 10.4108/eai.24-11-2023.2346493

found that climate factors are changing due to increasing greenhouse gas (GHG) emissions in the atmosphere worldwide [6], [7]. High GHG emissions significantly cause global warming and climate variability [8]. The findings show that climate change has several negative implications for all economic sectors. However, agriculture is the most vulnerable sector directly affected.

Substantial evidence has often been obtained through previous research results that temperature levels have increased and impact the activity and productivity of the agricultural sector [9]. The negative impacts of climate change can be seen in decreasing crop yields, increasing food prices, changes in land use, increasing pest attacks, and difficulties in agricultural managemen [10]. Another fact has been found that climate change significantly impacts farmers' income and technical efficiency [11]. Changes in rainfall patterns, increasing temperatures and weather anomalies due to climate change can cause a decrease in corn production. Farmers also face challenges such as increasing pest and disease attacks on crops [12].

A decrease in corn production due to climate change can reduce farmers' income because reduced production results in decreased income from the harvest [11]. Research [13], [14] found that climate change and its negative impacts put greater pressure on society's ability to increase technical efficiency in agricultural businesses, leading to lower production yields and incomes. Climate change is prone to pose a high risk to agricultural and coastal areas [15], one example of which is Indonesia. Meanwhile, in terms of contribution, the agricultural sector is the backbone of the community economy [18]. The community's high dependence on rain-fed agriculture increases its vulnerability to the impacts of climate change and variability [16].

Farming production in Indonesia is already below potential yields due to deteriorating soil conditions. [17] believes that countries with a large part of the coastline with the main activity of their people as farmers are more at risk of climate change regardless of their insight in responding to climate change adaptation. Thus, it is evident that the status of people who act as farmers is very dependent on the climate [18], [19]. This fact can be indicated by climate shocks such as drought and floods affecting agricultural land throughout the country. Climate change can disrupt the sustainability of rainfed maize farming, affecting the quality and quantity of harvests and increasing production costs [20]. In the face of climate change, rainfed corn farmers may experience declining income and technical efficiency in their agricultural activities. The vulnerability of rainfed maize farmers to climate change can be seen through changes in their income and technical efficiency [21].

This climate change has made households and communities in Indonesia vulnerable to poverty due to low production output. This condition will also impact the low income-of the farming community, reducing their security and social resilience [22], [23]. Responding to the impact of climate change, farmers are involved in implementing several adaptation strategies to gain technical efficiency during farming management. Insight into climate change is necessary to increase production and income [24].

Several studies have found that climate change has a significant impact on agricultural production and results in an increase in plant diseases and insect pests. Production and income risks may also increase, decreasing land quality [25], [26]. Research on the impact of climate change on rainfed corn farmers is scarce but only focuses on rice crops in general [27]–[30]. In addition, previous research also examined farmers' adaptation strategies to climate change [31]–[34], which were not linked to technical efficiency in corn crops and climate change. Therefore, to fill the gap in previous research, this research will examine the specific impacts of climate change on rain-fed corn farmers.

The approach used by the objectives of this research has yet to be studied extensively and provides a new perspective on understanding the impacts of climate change on rain-fed maize farmers. In addition, through this research, we will explore the adaptation strategies of corn farmers and highlight other potential contributions that will be found in this research so that rain-fed corn farmers can use the results of this research as a reference for reducing the impact of climate change. Although there have been many previous studies discussing the impact of climate change on rice farmers' income [35], the impact of climate change on food crop production [36], the impact of climate change on the productivity and income of chilli farmers [37], the impact of climate change on nutmeg production [38], the impact of climate change on rice production [39], Adaptation to climate change and the income structure of corn farmers [40]. However, climate change that focuses on climate change associated with production and income and the technical efficiency of rainfed corn farmers is rarely implemented. Most previous studies also analyzed and measured climate change and its relationship to production and income using different analyses to those carried out in this research.

This research will evaluate production results, considering farmers' income levels and technical efficiency under climate change conditions. The stochastic frontier analysis (SFA) method used in this research aims to estimate technical efficiency, while previous research used the Data Envelopment Analysis (DEA) method. DEA is a nonparametric estimation method that does not require a particular estimation function. More suitable for comprehensively evaluating company efficiency. Agricultural production involves many uncertain factors, which can affect the outcome. In this context, DEA methods can overestimate technical efficiency without considering random errors. In this study, we decided to use stochastic frontier analysis (SFA) because the SFA method is a parametric method that can effectively control random errors caused by data problems. Measuring and analysis tools that use stochastic frontier analysis (SFA) on the technical efficiency of corn farmers due to climate change are rarely discussed in previous research.

2 Method

2.1 Research Data

This research used the Multistage sampling method to determine the location. The first stage selects a province and selects two districts or cities. Sumenep and Pamekasan were chosen deliberately because they have corn commodity potential and are dry land areas (figure 1). The second stage selects sub-districts and villages based on information from authorized institutions (Agriculture Department and Agricultural Extension Center). Lenteng sub-district represents Sumenep, and Larangan sub-district represents Pamekasan in this study.

Corn farmer respondents were chosen deliberately by considering that the respondents were corn farmers with a rain-fed farming system and had access to information that was easier to obtain. We selected 35 farmers in each district as respondents, so the total respondents in this study were 70 farmers. The enumerators in this research were local university students who understand Indonesian and Madurese. Data was collected from interviews and structured surveys using questionnaires focused on rain-fed corn farming activities.

Fig. 1. The Location of the study area in East Java, Indonesia

2.2 Data Analysist

2.2.1 Income Farmers Analysis

Estimating farming costs is essential to determine the level of income of corn farmers on rainfed land during climate change, following the following functions:

$$\pi = TR - TC \quad (1)$$

where π is the level of income, TR is total income and TC is total costs.

2.2.2 Technical Efficiency

We use the Cobb-Douglas Stochastic Frontier production function to estimate production factors and technical efficiency that influence corn farming production. The dependent variable is production level, and the independent variable is production input. The Cobb-Douglas Stochastic Frontier production function model is as follows:

$$ln\, Y = \beta_0 + \beta_i lnX_i + v_i - u_i \quad (2)$$

Where *ln Y* is the logarithmic result of the production level, β_i is coefficient *vi-ui* is a source of inefficiency and *error terms*. So the function for estimating technical efficiency is as follows:

$$ET_G = \left(\frac{1}{n}\right)\sum_{i=1}^{n} \left(\frac{Y_i}{Y_i^{\wedge}}\right) \quad (3)$$

ET_G is the result of estimating the technical efficiency of the respondent group, Y_i is the amount of output-I, $Y_i^{\wedge}$ is the production quantity estimated at the first observation obtained from the Cobb-Douglass frontier production function. The technical efficiency value ranges from 0 – 1. To estimate the effect of technical inefficiency, follow the following function:

$$ui = \delta_0 + \delta_i Z_i \quad (4)$$

Where *ui* is the effect of technical inefficiency, δ_i is a constant Z_i is variable i. To help analyze technical efficiency and inefficiency factors, we use help from the Frontier 4.1 application.

3 Result and Discussion

3.1 Income Maize Farmers

Cannot be denied that the long dry season due to climate change impacts the income of rain-fed corn farmers in East Java. Several studies have proven this impact, one of which is [11] . To examine the income results from rainfed corn farming during climate change, we present them in **Table 1.**

Tabel 1. Income Maize Farmers Estimation

Description	Average		(%)	Conversion (hektare)		(%)
	Requirements	Cost		Requirements	Cost	
Fixed Cost						
Land tax (Ha)	0.71	IDR 352,857	14.56	1.00	IDR 500,000	13.86
Tool depreciation		IDR 275,267	11.36		IDR 435,872	12.08
Total Fixed Cost	**IDR 628,124**		25.93	**IDR 935,872**		25.94
Variabel Cost						
Seed (Kg)	9.81	IDR 294,193	12.14	14	IDR 422,143	11.70
Labor (HOK)	11.84	IDR 743,205	30.68	19.9	IDR 1,159,797	32.14
Pesticide (liter)		IDR 153,354	6.33		IDR 238,388	6.61
Fertilizer (Kg)		IDR 603,790	24.92		IDR 852,114	23.62
Total Variabel Cost	**IDR 1,794,543**		74.07	**IDR 2,672,442**		74.06
Total Cost	**IDR 2,422,667**			**IDR 3,608,313**		
Revenue						
Production	3013.90	**IDR 9,041,786**		4261.40	**IDR 12,784,286**	
Income	**IDR 6,619,119**			**IDR 9,175,972**		
R/C		3.70			3.50	

Note : Conversion per hectare per crop season

Table 1 shows that the average income level of rainfed land farmers in one planting season is IDR 6,619,119, while the income level of farmers in conversion to needs per hectare is IDR 9,175,972. The results in Table 1 above show that the income level of rainfed corn farmers is lower than before the long dry season, for example, in research [41]. This shows that there is a need for adaptation strategies, either in the form of farmer management or contributions from the government, so that the level of productivity of corn farming in East Java remains optimal and does not reduce farmers' income. This narrative is following research [9], [37].

3.2 Technical Efficiency Farmers

Many studies have investigated the technical efficiency results of corn farming in various regions, including East Java. Researchers will present the results of estimating the influence of input factors on production results and technical efficiency using Stochastic Frontier Analysis (SFA). In Table 2, we can see the factors that influence the production of rainfed corn farming.

Table 2. Factor Affecting Maize Production

Variable	Final MLE Estimates	
	Coefficient	**Std. Error**
Constanta	3.350	0.106
Seed	0.133***	0.026
Urea fertilizer	0.485***	0.032
Organic fertilizer	0.267***	0.045
NPK fertilizer	0.077***	0.017
Labor	0.062	0.062
sigma-squared	-0.016***	0.001
gamma	0.999***	0.000

Note : *,**,*** denote significant on 10%, 5% and 1%

Four of the five variables included in the model have a significant effect within an error level of 1%, namely seed, urea fertilizer, organic fertilizer and NPK fertilizer. The coefficient value of the urea fertilizer variable has the highest value, namely 0.485. In conditions where the land is dry and difficult to irrigate because the type of land at the research location is rain-fed, urea fertilizer will be helpful as a source of nutrition for corn plants, which will support the growth of stems, leaves and roots. Second, urea fertilizer, which contains nitrogen in one study, also increased chlorophyll levels, leaf area, photosynthesis rate and corn productivity, especially in precise doses on dry land [42]. This means that the application of urea fertilizer to rainfed land could be more optimal and can still be improved to increase productivity. Next, Table 3 will show the results of the technical efficiency of corn farming on rainfed land in East Java.

Table 3. Technical Efficiency Maize Farmers

Technical Efficiency	Farmers	%
0 - 0.2	0	0.000
0.21 - 0.40	0	0.000
0.41 - 0.60	1	1.400
0.61 - 0.80	23	32.900
0.81 - 1.00	46	65.700
Total Farmers	70	
Average	0.829	
Min	0.560	
Max	0.999	

Four of the five variables included in the model have a significant effect within an error level of 1%, namely seed, urea fertilizer, organic fertilizer and NPK fertilizer. The coefficient value of the urea fertilizer variable has the highest value, namely 0.485. In conditions where the land is dry and difficult to irrigate due to type l, the estimated average value of technical efficiency for corn farmers in East Java on rainfed land is 0.829. We can also assess these results as an illustration of the managerial abilities of rain-fed farmers, especially during extended dry periods due to climate change. Farmers with a technical efficiency score of 0.81 – 1.00 are the technical efficiency score group with the highest percentage. Based on this average value, farmers can be categorized as technically efficient [43]. This average value is lower than previous research in the same area and is rainfed land [44]. Furthermore, to find out the estimation results of factors that influence technical inefficiency in rainfed corn farming in East Java, you can see the results of the Final MLE estimates analysis in **Table 4.**

Table 4. Factor Affecting Inefficiency

Variable	Final MLE Estimates	
	Coefficient	**Std. Error**
Constanta	-0.137	0.087
Education (years)	-0.008	0.073
Experience (years)	0.220***	0.094
Agricultural counseling (times)	-0.060***	0.002
Farmers group (1 if farmers join farmer group; 0 otherwise)	-0.324***	0.112
sigma-squared	-0.016	0.001
gamma	0.999	0.000

Note : *,**,*** denote significant on 10%, 5% and 1%

Based on Table 4, we can see the estimation results of farmers' social factors that influence inefficiency. The variables experience, agricultural counselling and farmers group have a significant effect at an error level of 1%. Farmers who join farmer's groups can overcome production inefficiencies and the Agricultural Counseling variable. Farmers' social activities, joining farmer's groups, and agricultural counselling are an effort to improve farmers' managerial abilities through training and counselling from authorized parties, one of which is the government through farmers. The role of farmer's groups and agricultural counselling is essential so that during the long dry season due to climate change, especially on rainfed agricultural land, farmers gain new knowledge to adapt to optimize production efficiency and farmer income.

4 Conclusion

Based on these two research objectives, in the context of climate change, rainfed corn farmers in East Java experience a decline in performance, especially in income and technical efficiency. Research findings show that variables such as experience, agricultural extension, and participation in farmer groups significantly impact farmers' levels of technical inefficiency. Therefore, the role of government, through agricultural extension and farmer groups, is crucial in providing knowledge related to climate change. The recommended next step is to conduct further research to explore adaptation strategies that rainfed corn farmers can implement in the face of climate change.

References

[1] A. Rahmat, “Comparative Concepts of Geopolitics, Social Culture and Economics of Developed Countries and Developing Countries” *J. Edukasia Multi Kult.*, vol. 3, no. 1, p. 17, 2021.

[2] I. A. Baig, A. A. Chandio, I. Ozturk, P. Kumar, Z. A. Khan, and M. A. Salam, “Assessing the long- and short-run asymmetrical effects of climate change on rice production: empirical evidence from India,” *Environ. Sci. Pollut. Res.*, vol. 29, no. 23, pp. 34209–34230, May 2022, doi: 10.1007/s11356-021-18014-z.

[3] H. Zhang, Y. Tang, A. A. Chandio, G. R. Sargani, and M. Ankrah Twumasi, “Measuring the Effects of Climate Change on Wheat Production: Evidence from Northern China,” *Int. J. Environ. Res. Public Health*, vol. 19, no. 19, p. 12341, Sep. 2022, doi: 10.3390/ijerph191912341.

[4] R. B. Pickson, G. He, and E. Boateng, “The impacts of climate change and smallholder farmers’ adaptive capacities on rice production in Chengdu, China: macro-micro analysis,” *Environ. Res. Commun.*, vol. 4, no. 7, p. 075011, Jul. 2022, doi: 10.1088/2515-7620/ac7949.

[5] E. Osei, S. H. Jafri, A. Saleh, P. W. Gassman, and O. Gallego, “Simulated Climate Change Impacts on Corn and Soybean Yields in Buchanan County, Iowa,” *Agriculture*, vol. 13, no. 2, p. 268, Jan. 2023, doi: 10.3390/agriculture13020268.

[6] Suminah and S. Anantanyu, “Strategy for empowering corn farmers due to climate change in Wonoharjo Village Kemusu Boyolali,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1165, no. 1, p. 012035, Apr. 2023, doi: 10.1088/1755-1315/1165/1/012035.

[7] A. Ishtiaque, “US farmers’ adaptations to climate change: a systematic review of adaptation-focused studies in the US agriculture context,” *Environ. Res. Clim.*, vol. 2, no. 2, p. 022001, Jun. 2023, doi: 10.1088/2752-5295/accb03.

[8] A. Accetturo and M. Alpino, “Climate Change and Italian Agriculture: Evidence from Weather Shocks,” *SSRN Electron. J.*, 2023, doi: 10.2139/ssrn.4464128.

[9] M. P. Sulbaek Andersen, O. J. Nielsen, and J. D. Sherman, “Assessing the potential climate impact of anaesthetic gases,” *Lancet Planet. Heal.*, vol. 7, no. 7, pp. e622–e629, Jul. 2023, doi: 10.1016/S2542-5196(23)00084-0.

[10] A. S. M. Abdullah, K. Dalal, A. Halim, A. F. Rahman, and A. Biswas, “Effects of Climate Change and Maternal Morality: Perspective from Case Studies in the Rural Area of Bangladesh,” *Int. J. Environ. Res. Public Health*, vol. 16, no. 23, p. 4594, Nov. 2019, doi: 10.3390/ijerph16234594.

[11] W. Tumwesigye, A. Aschalew, W. Wilber, and A. Destra, “Impact of Climate Change on Food Systems: A Narrative Review,” *J. Water Resour. Ocean Sci.*, vol. 8, no. 4, p. 50, 2019, doi: 10.11648/j.wros.20190804.12.

[12] V. Chvátalová, “Czech Farmers’ Experience with Bt Maize: Fulfilment, and the Opposite, of Monsanto’s Promises,” *Acta Univ. Agric. Silvic. Mendelianae Brun.*, vol. 68, no. 1, pp. 25–38, Feb. 2020, doi: 10.11118/actaun202068010025.

[13] P. A. Collins-Sowah, K. C. Adjin, C. H. C. A. Henning, and E. A. Kanu, “Risk

management under climate change and its implication on technical efficiency: Evidence from Senegal," *Q Open*, vol. 3, no. 1, Jan. 2023, doi: 10.1093/qopen/qoad006.
[14] T. Haryanto, W. W. Wardana, and J. A. Q. Basconcillo, "Does sending farmers back to school increase technical efficiency of maize production? Impact assessment of a farmer field school programme in Indonesia," *Econ. Res. Istraživanja*, vol. 36, no. 3, Dec. 2023, doi: 10.1080/1331677X.2023.2218469.
[15] M. Ahmed *et al.*, "Impact of Climate Change on Dryland Agricultural Systems: A Review of Current Status, Potentials, and Further Work Need," *Int. J. Plant Prod.*, vol. 16, no. 3, pp. 341–363, Sep. 2022, doi: 10.1007/s42106-022-00197-1.
[16] S. B. Opiyo, S. Letema, and G. Opinde, "Characterizing rural households' livelihood vulnerability to climate change and extremes in Migori River Watershed, Kenya," *Clim. Dev.*, pp. 1–19, Aug. 2023, doi: 10.1080/17565529.2023.2243612.
[17] T. M. Cao, S. H. Lee, and J. Y. Lee, "The Impact of Natural Disasters and Pest Infestations on Technical Efficiency in Rice Production: A Study in Vietnam," *Sustainability*, vol. 15, no. 15, p. 11633, Jul. 2023, doi: 10.3390/su151511633.
[18] S. Abdul Wahab and Z. Shah, "The Nature and Extent of Technical Efficiency of Maize Production for Smallholder Farmers in Conflict-Prone Areas," *Technol. Environ.*, vol. 2, no. 1, pp. 1–14, 2023, doi: 10.53797/agrotech.v2i1.1.2023.
[19] M. OUÉDRAOGO, S. BARRY, and R. B. ZOUGMORÉ, "How Using Weather And Climate Information Services May Impact Farm Productivity And Technical Efficiency: Evidence From Cowpea And Sesame Producers In Burkina Faso," *Clim. Chang. Econ.*, vol. 14, no. 02, May 2023, doi: 10.1142/S2010007823500112.
[20] A. Singamsetti *et al.*, "Genetic gains in tropical maize hybrids across moisture regimes with multi-trait-based index selection," *Front. Plant Sci.*, vol. 14, Mar. 2023, doi: 10.3389/fpls.2023.1147424.
[21] B. Lankford and S. Orr, "Exploring the Critical Role of Water in Regenerative Agriculture; Building Promises and Avoiding Pitfalls," *Front. Sustain. Food Syst.*, vol. 6, Jun. 2022, doi: 10.3389/fsufs.2022.891709.
[22] M. T. Cobbinah, G. Danso-Abbeam, and A. A. Ogundeji, "Access to mutual labour support in agriculture: Implications for maize productivity and efficiency of farmers in northern Ghana," *Agrekon*, vol. 62, no. 1, pp. 61–79, Jan. 2023, doi: 10.1080/03031853.2022.2156898.
[23] D. J. M.-B. File, F. X. Jarawura, and E. K. Derbile, "Adapting to climate change: Perspectives from smallholder farmers in North-western Ghana," *Cogent Soc. Sci.*, vol. 9, no. 1, Dec. 2023, doi: 10.1080/23311886.2023.2228064.
[24] S. Paroon, G. R. Yavari, and M. Rezazadeh, "Impacts of Climate Change on Watermelon and Cucumber Agriculture in Hormozgan Province and Prediction of Long-Term Pattern," *Geogr. Res. Q. J.*, vol. 34, no. 3, pp. 347–355, Sep. 2019, doi: 10.29252/geores.34.3.347.
[25] A. S. Linda Ayu Vivi Andriyani1*, Titik Ekowati2, " Technical and Economic Efficiency Analysis of Shallot Farming At Panekan, Magetan" vol. 7, pp. 270–282, 2023.
[26] Sarini Sri Utari, D. Rachmina, and N. Tinaprilla, " Technical Efficiency of Shallot Farming Business in Aceh Province" *J. Ilmu Pertan. Indones.*, vol. 28, no. 1, pp. 114–122, Dec. 2022, doi: 10.18343/jipi.28.1.114.
[27] S. Handayani, S. P. Lestari, E. Aryani, and M. Kristina, "Technical efficiency of organic rice farming in Lampung province " *J. Ekon. Pertan. dan Agribisnis*, vol. 7, pp.

1169–1178, 2023.
[28] T. N. Astuti, F. E. Prasmatiwi, and K. Murniati, " Technical Efficiency of People's Sugarcane Farming Using the Stochasic Frontier Approach in North Lampung Regency" *J. Food Syst. Agribus.*, vol. 5, no. 2, pp. 156–165, 2021, doi: 10.25181/jofsa.v5i2.1952.
[29] D. Damayanti, I. Irmayani, and Darmawan, " Analysis of the Efficiency of Rice Farming Using the Combine Harvester Machinery System in the Harvesting Process in Padangloang Village, Dua Pitue District, Sidenreng Rappang Regency" *J. Saintifik (Multi Sci. Journal)*, vol. 21, no. 3, pp. 115–124, Oct. 2023, doi: 10.58222/js.v21i3.161.
[30] L. Yuliyani, R. Salam, R. R. Bahar, T. Hartoyo, and D. A. Pramita, " Analysis Of Rice Farming Efficiency Based On Seasons In Indonesia" *J. Agristan*, vol. 5, no. 1, pp. 74–87, May 2023, doi: 10.37058/agristan.v5i1.7117.
[31] L. Soltani and T. Mellah, "Exploring farmers' adaptation strategies to water shortage under climate change in the Tunisian semi-arid region," *Environ. Manage.*, vol. 71, no. 1, pp. 74–86, Jan. 2023, doi: 10.1007/s00267-022-01604-z.
[32] B. A. Magesa, G. Mohan, H. Matsuda, I. Melts, M. Kefi, and K. Fukushi, "Understanding the farmers' choices and adoption of adaptation strategies, and plans to climate change impact in Africa: A systematic review," *Clim. Serv.*, vol. 30, p. 100362, Apr. 2023, doi: 10.1016/j.cliser.2023.100362.
[33] A. F. Akpa, C. J. Amegnaglo, and A. F. Chabossou, "Climate change adaptation strategies and technical efficiency of maize producers in Benin, West Africa," *Int. J. Product. Perform. Manag.*, May 2023, doi: 10.1108/IJPPM-06-2022-0284.
[34] Y. Shabani and N. M. Pauline, "Perceived Effective Adaptation Strategies against Climate Change Impacts: Perspectives of Maize Growers in the Southern Highlands of Tanzania," *Environ. Manage.*, vol. 71, no. 1, pp. 179–189, Jan. 2023, doi: 10.1007/s00267-021-01563-x.
[35] P. Geografi, "Dampak Perubahan Curah Hujan Terhadap Pendapatan Petani Padi Di Desa Kombo Kecamatan Dampal Selatan Kabupaten Tolitoli," vol. 1, no. 2, pp. 111–118, 2023.
[36] L. R. E. Malau, K. R. Rambe, N. A. Ulya, and A. G. Purba, "Dampak perubahan iklim terhadap produksi tanaman pangan di indonesia," *J. Penelit. Pertan. Terap.*, vol. 23, no. 1, pp. 34–46, Mar. 2023, doi: 10.25181/jppt.v23i1.2418.
[37] A. Naura and F. D. Riana, " The Impact of Climate Change on Red Chili Farming Production and Income (Case in Sumberbendo Hamlet, Kucur Village, Malang Regency)" *J. Ekon. Pertan. dan Agribisnis*, vol. 2, no. 2, pp. 147–158, Feb. 2018, doi: 10.21776/ub.jepa.2018.002.02.8.
[38] I. J. Lawalata, H. Rehatta, S. Leimaheriwa, and J. A. Leatemia, "The Effect Of Climate Change On Productivity Of Clove (Syzigium Aromaticum) In Haruku Island, Central Maluk Regency," *Agrologia*, vol. 12, no. 1, p. 99, Apr. 2023, doi: 10.30598/ajibt.v12i1.1808.
[39] H. Puspita Sari and S. K. Sari, " Impact of Climate Change on Rice Production" *Sci. Res. J. Mai Wandeu*, vol. 2, no. 1, pp. 88–89, 2022.
[40] P. S. District, S. L. Regency, K. Murniati, A. Nugraha, and R. Rahmadani, "Climate Change Adaptation and Income Structure of Corn Farmers in Penengahan District, South Lampung Regency " vol. 1, no. 2, pp. 56–64, 2022.
[41] M. W. Firdaus, M. Hayati, and T. R. D. A. Nugroho, "Performance and Income Level of Corn Partnership Farmers in The Pamekasan District," in *SEMAGRI*, 2022, no. 3, pp. 84–92.

[42] J. H. H. Sonbai, “Growth and Yield of Corn on Various Applications of Nitrogen Fertilizer in Regosol Dry Land,” *PARTNER*, vol. 20, no. 2, pp. 1–11, 2013.
[43] M. W. Firdaus and E. Fauziyah, “Economic Efficiency of Hybrid Corn Farming on Madura Island,” *AGRISCIENCE*, vol. 1, no. 1, pp. 74–87, 2020.
[44] Z. Hasan and E. Fauziyah, “Use of Production Factors and Level of Technical Efficiency Hybrid Corn Farming in Madura,” *Agriscience*, vol. 1, no. 1, pp. 50–60, 2020, doi: 10.21107/agriscience.v1i1.7507.