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# The Effect Of Land Area And Hot Weather Conditions On The Rice Production Of Farmers In Poboya Village, Mantikulore District, Palu City, Central Sulawesi

**Arifuddin Lamusa[1], Faruq A.H Lamusa[2]**
[1]Department of Agribu siness Faculty of Agriculture, Tadulako University.Palu City, Central Sulawesi.Indonesia.orcid.org/0009-0004-5707-805X
[2]Department of Management Faculty of Economics Tadulako University, .Palu City, Central Sulawesi.Indonesia
Correspondence Email.lamusa.arif@yahoo.com (L.A.Y); lamusaarifuddin@gmail.com (L.A.G)

***Abstract:*** *. This study aimed to obtain information about the impact of land area and hot weather conditions on rice farming in Poboya, Mantikulore District, Palu City, Central Sulawesi. The total population of rice farmers in the Poboya village, Mantikulore District, comprised 42 individuals, all of whom were included in the study using a census method. Multiple linear regression analysis was used to examine whether the independent variables significantly influenced the dependent variable, expressed as* $Y = a + b_1X_1 + b_2X_2 + e$*, using SPSS 26 for data analysis. The independent variables were land area and hot weather conditions, while the dependent variable was the rice production in Poboya. The results of the analysis are as follows: (1)The regression coefficient for X1 was 0.849, indicating that a unit increase in land area leads to an 84% increase in rice production. (2) The regression coefficient for X2 was -0.354, suggesting that hot weather conditions do not positively affect rice production. A temperature rise of 35 degrees Celsius could decrease rice production by 35%. This effect is attributed to the adverse hot weather conditions prevalent in Palu City.*

***Keywords:*** *Land Area, Hot Weather Conditions, Rice Production*

## 1. INTRODUCTION

Central Sulawesi is a region where the majority of the population works as farmers, cultivating rice paddies for food consumption and agricultural production. It is also one of the provinces that play a significant role in supplying the national stock. To maintain this achievement, the local government has established the "Tri Program" as a regional development strategy(Arifah et al., 2023; Sofiyuddin et al., 2021). This strategy includes changing mindsets, regionalizing commodities, and implementing the harvest-process-sell approach, as well as strict certification standards for seeds, both in the field and laboratory, to preserve varietal purity (BPTP, 2009).

Rice farming is a vital source of income and employment for rural communities, thus requiring efficient management and utilization of production factors(Effendy et al., 2022; Sitaresmi et al., 2023). Inefficient use of production factors in rice farming results in low production and high costs, ultimately reducing farmers' income. For farmers, agricultural activities are not only about increasing production but also about raising income through the efficient use of production factors. Often, the addition of production factors does not yield the expected income for farmers(Gamayanti et al., 2023; Silva et al., 2022)

Rice is the ultimate product of the paddy plant(Mohidem et al., 2022; Rafiuddin et al., 2021) Rice is derived from the paddy plantation; rice is the staple food for half of the Asian population. In Indonesia alone, rice has become the primary food commodity; it functions as a strategic commodity characterized by heightened political-economic sensitivity and significant social vulnerability(Al-hashimi, 2023; Dorairaj & Govender, 2023) Rice is subsequently significantly demanded by the Indonesian populace; even minor disruptions, such as crop failures, can significantly impede the supply chains, leading to escalated commodities market prices (Busungu, 2023; Ermanto et al., 2021)

Central Sulawesi Province is one of the main rice-producing areas in Indonesia, with an average production from 2017 to 2021 of approximately 1,287,521 tons per year (BPS, 2022). Despite annual fluctuations, this figure represents a significant contribution to fulfilling the demand for staple rice both at the regional and national levels, as well as supporting the livelihoods of farmers(Hafif et al., 2024; Rauf et al., 2023) The developments in harvested area, production, and productivity of rice in Central Sulawesi

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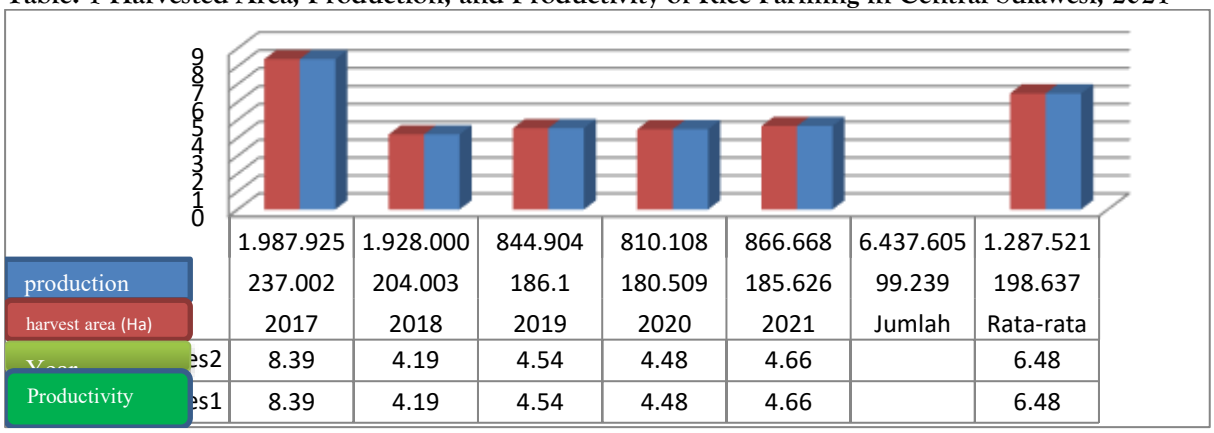
are presented in Table 1.

**Table. 1 Harvested Area, Production, and Productivity of Rice Farming in Central Sulawesi, 2021**



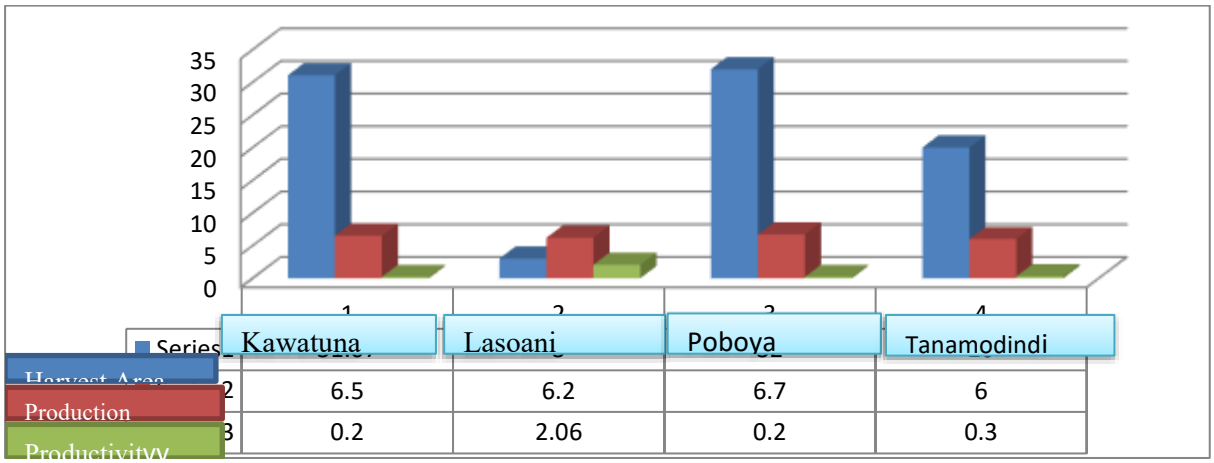

| | 1.987.925 | 1.928.000 | 844.904 | 810.108 | 866.668 | 6.437.605 | 1.287.521 |
|---|---|---|---|---|---|---|---|
| | 237.002 | 204.003 | 186.1 | 180.509 | 185.626 | 99.239 | 198.637 |
| | 2017 | 2018 | 2019 | 2020 | 2021 | Jumlah | Rata-rata |
| es2 | 8.39 | 4.19 | 4.54 | 4.48 | 4.66 | | 6.48 |
| es1 | 8.39 | 4.19 | 4.54 | 4.48 | 4.66 | | 6.48 |

Source: Central Bureau of Statistics (BPS) of Central Sulawesi Province, processed into a diagram, 2022

Table 1 shows that the rice production in Central Sulawesi fluctuated during the period 2017 – 2021, with an average reaching 1,287,521 tons/year and a harvested area of 198,637 ha. There were decreases and increases in the harvested area and production in Central Sulawesi from 2017 to 2021 due to varying contributions from different districts and cities.

This is because Palu City has not fully optimized its agricultural land; most of Palu's population work outside the agricultural sector, such as in administrative roles (offices, construction laborers, factory workers). However, a small portion still relies on agriculture, particularly rice farming. Palu consists of eight districts, of which only three have an agricultural sector specializing in rice farming. The following are the districts contributing to the harvested area, production, and productivity of rice.

**Table 2. Harvested Area, Production, and Productivity of Rice Farming by District in Mantikulore 2021.**




| | | | | |
|---|---|---|---|---|
| 2 | 6.5 | 6.2 | 6.7 | 6 |
| 3 | 0.2 | 2.06 | 0.2 | 0.3 |

Source: Central Sulawesi Provincial Agricultural Department, 2022

Table 2 indicates that Poboya Village is one of the villages with a significant agricultural sector, specifically in rice farming, with a harvested area of 32.00 hectares and a production of 6.7 tons, yielding a productivity of 0.2 tons/ha. The average landholding size for rice farmers in Poboya Village is approximately 0.69 hectares. Farmers, acting as managers, are highly rational in making decisions about the agricultural operations they manage with the objective of maximizing profit(Arifuddin Lamusa & Prof. Dr. Ir. Sri Widodo, M.Sc, 2010). This management does not only seek to increase production but also to enhance income through the use of production factors, as it is often observed that adding production factors does not yield the expected income increase for farmers(Cass et al., 1994; Norfahmi et al., 2021)

Commercialization in rice farming requires planning and government support to achieve the desired

goals, which include not only increasing farmers' income but also ensuring the continuity of their contributions to regional and national earnings(Arifah et al., 2023; Septiana et al., 2019)
Rice cultivation is one of the livelihood sources and a source of income for a small segment of the community and farmers in Poboya Village. Farmers in Poboya Village have never conducted an income analysis to determine the actual income received from rice farming(Anda et al., 2021; Sumarniasih et al., 2022) Income and profit are calculated based on total receipts minus all costs incurred in rice management, ranging from equipment and materials to other expenses that may affect the profitability of the farmers. Therefore, it is necessary to analyze the income from rice farming in Poboya Village, Mantikulore District, Palu City.

### 1.1 Problem Statement

impact of capital and extreme heat factors on the revenue of rice farming in Poboya Village, Mantikulore District, Palu City?

### 1.2 Research Objectives

Based on the problem statement described, the objective of this research is to determine the impact of capital and weather factors on the revenue of rice farming in Poboya Village, Mantikulore District, Palu City.

### 1.3 Benefits of the Research

The benefits of this study are as follows:
1. To serve as a source of information for all stakeholders, especially for rice farmers in Poboya Village, Mantikulore District, Palu City.
2. To enhance and develop knowledge on the relationships between capital and weather factors and farmers' income in rice farming activities.
3. To provide reference material for further research addressing similar issues in efforts to increase income.

## 2. MATERIALS AND METHODS

### 2.1 Research Design

The data used in this study are quantitative. Quantitative data analysis involves numerical values, thus requiring the classification of data into specific categories using relevant tables to examine the relationships between endogenous variables and exogenous variables.

### 2.2 Population and Sample

The population of this study consists of all the rice farmers in Poboya Village, Mantikulore District, Palu City. The total population includes 42 rice farmers, all of whom were included in the study using a census method Therefore(**Ahmadini et al., 2024; Yuliarso et al., 2020**)the sample for this research comprises these 42 rice farmers from Poboya Village, Palu City.

### 2.3 Data Analysis Method

Multiple linear regression analysis was utilized to determine whether the independent variables collectively influence the dependent variable, represented by the equation: $\mathbf{Y = a + b_1X_1 + b_2X_2 + e}$
Y = Production
X1 = Land Area
X2 =Hot Weather Factor

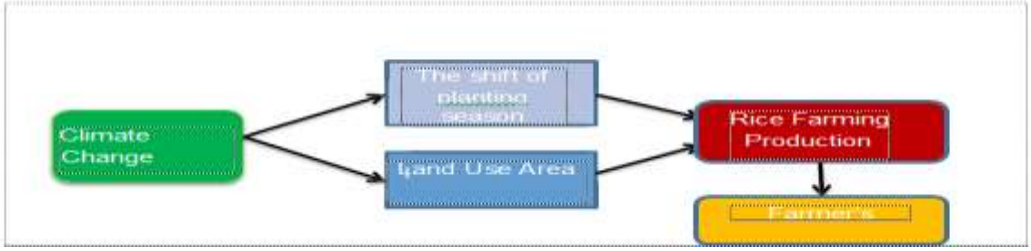


**Figure 1**. Conceptual Framework

### 2.4 Conceptual Framework

The Village of Poboya is hindered by climate change. The impact of the climate change especially on rice farming includes the shifting of planting season, land area coverage and crops, which affect the production levels of rice yields in Poboya Village, Mantikulore District, Palu City, Central of Sulawesi and their study are needed. The aims of this study are consequently, enhancing the farmer community understanding of impacts and risks of climate change, can be achieved by implementing Teknologi Tepat Guna (TTG) /appropriate technology systems

## 3. RESULTS AND DISCUSSION

### 3.1 Study Area

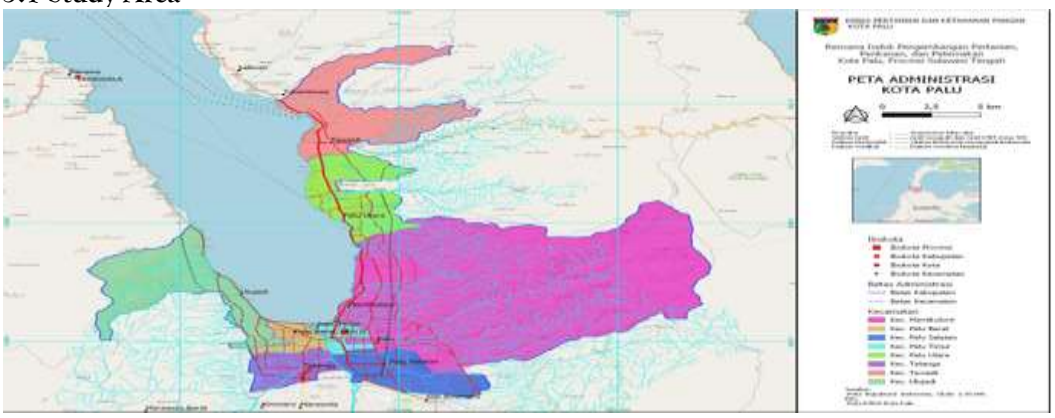



Figure 2. Sources City Palu Security food and Agricultural Department, 2021

This research aimed to determine the influence of weather conditions and land use of paddy rice farming in Poboya Village, Mantikulore District, Palu City. The sample collection is shown in Figure 2. It was observed during crop cultivation, starting from the beginning of cultivation until the final harvest of unhusked rice (gabah) over a period of 3-4 months. This study examined the impact of weather and planting area on paddy rice in farming production settings. The sample comprises rice farmers who are directly involved by them in the entire crop production process, from the vegetative to generative stage, in the hilly area of Palu City

### 3.2 Factors Influencing Rice Farmers' Income

#### 3.2.1 Capital

agricultural economic perspective, land can be considered the primary basis for potential activities, namely its ability to produce goods dependent on nature. According to the general Indonesian dictionary, 'lahan' refers to open land and cultivated land. Cultivated land is open land used for agricultural fields. Thus, 'lahan' can be defined as a place or land that has an area(Anda et al., 2021)

notes that money is one form of wealth, just as there are two types of capital: fixed and working capital. Fixed capital is translated into production costs through depreciation and interest on capital. Working capital directly becomes production costs with the amount of these costs equal to the value of the working capital. The production of each agricultural subsector is influenced by the working capital production factor. The higher the working capital per business unit used, the better the expected production outcomes for rice agriculture, a process termed capital-intensive or more intensive(Cass et al., 1994 )

### 3.3 Land Area

Land is the most fundamental resource, particularly in agricultural production. Therefore, it is one of the most critical production factors, as noted by (Nasikh et al., 2021), who stated that land, as a production factor, serves as the factory for agricultural outputs where production takes place and yields output. Land has a unique characteristic compared to other production factors: its area is relatively fixed, and the demand for land continues to increase, making it scarce(Habib-ur-Rahman et al., 2022; Rusmayandi et al., 2023)

### 3.4 Technology (Tools and Machinery)

Technology refers to the way various natural resources, capital, labor, and skills are combined to achieve production goals.(Midden et al., 2007; Ruzzante et al., 2021)Technology is closely related to the equipment and methods used in the production process of an industry. Agricultural technology includes the tools, methods, or techniques used in processing agricultural inputs to produce useful and successful

outputs, whether raw materials, semi-finished, or finished products(Abbasi et al., 2022; Mailena et al., 2021)

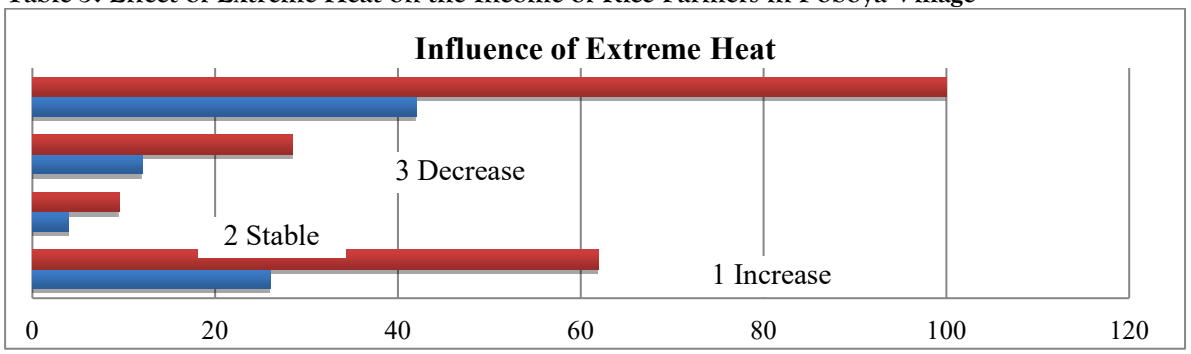
### 3.5 Impact of Climate Change on Rice Farming

Climate change affects various sectors, including resources, agricultural infrastructure, and agricultural production systems, as well as issues related to food security and self-sufficiency, all of which are influenced by climate change(**Dhamira & Irham, 2020; Saud et al., 2022; SIM et al., 2012**)In this study, several indicators of climate change impacts on rice farming that affect farmers' income were identified, such as shifts in planting seasons, increased attacks by pests, and decreased production yields(**Arifah et al., 2023; Hussain, 2024; Murniati & Mutolib, 2020**)

### 3.6 Weather Factor in Production Decline

In the agricultural industry, risk can be seen as a possibility that can result in losses, demonstrated by decreased crop output(**Aditto et al., 2012; Jankelova et al., 2017**) The risk of reduced output includes the potential decrease in farmers' welfare and reduced food availability in a region. One of the risks of reduced production in rice farming can be influenced by natural phenomena such as extreme weather, which may include relatively high temperatures and high rainfall intensity(**Burliai et al., 2021; Komarek et al., 2020**) High temperatures have significant negative impacts on agriculture, both directly and indirectly. The direct effects of high temperatures include crop damage, irregular root and shoot development, among others. Meanwhile, the indirect effects can be observed through aspects such as lower harvest yields and higher production costs.(**Dhamira & Irham, 2020; Kicińska & Wikar, 2021**)

**Table 3. Effect of Extreme Heat on the Income of Rice Farmers in Poboya Village**




Source: Primary Data Processed, 2023

Based on Table 3, it can be observed that the majority of respondents, amounting to 62.1%, experienced a decrease in production yields during periods of relatively high temperatures. This is attributed to the increased attacks by pests, which reproduce rapidly in relatively hot and humid conditions at night. Meanwhile, 27.6% of respondents reported that their rice production remained stable or was not affected by high temperatures, and 9.52% of respondents indicated that high temperatures led to an increase in their rice production

**Table 4. Research Variables**

**Variables Entered/Removed[a]**

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | Weather Factors Ln_X2, Land Area Ln_X1[b] | . | Enter |

a. Dependent Variable: Production Ln_Y

b. All requested variables entered.

**Source:** Primary Data Processed, 2023

Table 4 shows the variables included in the independent and dependent variables. Using SPSS 26 tools, the independent variables (X) are Land Area and Weather Factors, while the dependent variable (Y) is the rice production of farmers in Poboya Village, Mantikulore District, Palu City, Central Sulawesi.

**Table 5. Model Summary**

**Model Summary**[b]

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .734[a] | .539 | .515 | .33078 | .539 | 22.804 | 2 | 39 | .000 | 1.842 |

a. Predictors: (Constant), Weather Factors Ln_X2, Land Area Ln_X1

b. Dependent Variable: Production Ln_Y

**Source:** Primary Data Processed, 2023

Table 5 explains the correlation value (R) of 0.734 and the percentage of the influence of the independent variables (X) on the dependent variable (Y). The influence of the independent variables on the dependent variable called the coefficient of determination, is obtained by squaring R. From this output, the coefficient of determination (R2) is 0.539, meaning that the influence of the independent variables (land area and weather factors) on the dependent variable (production) is 53.9%, while the remaining 46.1% is influenced by other factors outside of the independent variables (X).

**Table 6. ANOVA**

**ANOVA**[a]

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 4.990 | 2 | 2.495 | 22.804 | .000[b] |
| | Residual | 4.267 | 39 | .109 | | |
| | Total | 9.257 | 41 | | | |

a. Dependent Variable: Ln_Y
b. Predictors: (Constant), Ln_X2, Ln_X1

**Source:** Primary Data Processed, 2023

The table above explains the ANOVA output. This section indicates whether there is a significant effect of the independent variables (land area and weather factors) on the dependent variable (rice production). From the output, it is evident that the calculated F value is 22.804 with a significance/probability level of 0.00 < 0.05. Thus, the regression model can be used to predict the rice production variable.

**Table 7. Coefficients**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 9.049 | 1.943 | | 4.656 | .000 |
| | Land Area Ln_X1 | .849 | .126 | .738 | 6.753 | .000 |
| | Weather Factors Ln_X2 | -354 | .561 | 169 | -631 | 532 |

Based on the analysis results in the table above, the regression equation can be derived to illustrate the

impact of land area and weather factors on rice production in Poboya Village, Mantikulore District, Palu City, Central Sulawesi, as follows:

$\hat{Y} = 0.904+0.849\ X1+0.354X2+\varepsilon$

The interpretation of the regression equation is as follows:

The constant value of 0.904 indicates a positive influence of the independent variable land area. If the independent variable increases by one unit, the rice production variable will increase or be fulfilled. The regression coefficient X1 of 0.849 indicates that if the land area increases by one unit, the rice production (Y) will increase by 0.849 or 84%. The regression coefficient X2 of -0.354 indicates that weather factors do not positively affect the increase in rice production. When the temperature reaches 35 degrees Celsius, it can decrease rice production by one unit, resulting in a decrease in production of -0.354 or 35%. This finding is consistent with (Keil, 2004) study, which concluded that extreme hot weather with rainfall less than 20mm/month cannot adequately support the existing rice fields, thereby reducing rice farming production in Central Sulawesi province.

## 4. CONCLUSION

Based on the results of the research and the discussion, the following conclusions can be drawn:

1. The regression coefficient X1 of 0.849 indicates that if the land area increases by one unit, the rice production (Y) will increase by 0.849 or 84%..
2. The regression coefficient X2 of -0.354 indicates that weather factors do not positively affect the increase in rice production. When the temperature reaches 35 degrees Celsius, it can decrease rice production by one unit, resulting in a decrease of -0.354 or 35%. This is due to the hot weather conditions prevalent in Palu City.

**REFERENCES**

1. Abbasi, R., Martinez, P., & Ahmad, R. (2022). The digitization of agricultural industry – a systematic literature review on agriculture 4.0. Smart Agricultural Technology, 2, 100042. https://doi.org/10.1016/j.atech.2022.100042
2. Aditto, S., Gan, C., & V., G. (2012). Sources of Risk and Risk Management Strategies: The Case of Smallholder Farmers in a Developing Economy. In N. Banaitiene (Ed.), Risk Management—Current Issues and Challenges. InTech. https://doi.org/10.5772/50392
3. Ahmadini, A. A. H., Singh, R., Raghav, Y. S., & Kumari, A. (2024). Estimation of population mean using ranked set sampling in the presence of measurement errors. Kuwait Journal of Science, 51(3), 100236. https://doi.org/10.1016/j.kjs.2024.100236
4. Al-hashimi, A. M. (2023). A Review: Growing Rice in the Controlled Environments. Biosciences Biotechnology Research Asia, 20(1), 13–28. https://doi.org/10.13005/bbra/3064
5. Anda, M., Purwanto, S., Suryani, E., Husnain, & Muchtar. (2021). Pristine soil property and mineralogy as the strategic rehabilitation basis in post-earthquake-induced liquefaction, tsunami and landslide in Palu, Indonesia. CATENA, 203, 105345. https://doi.org/10.1016/j.catena.2021.105345
6. Arifah, Salman, D., Yassi, A., & Bahsar Demmallino, E. (2023). Knowledge flow analysis of knowledge co-production-based climate change adaptation for lowland rice farmers in Bulukumba Regency, Indonesia. Regional Sustainability, 4(2), 194–202. https://doi.org/10.1016/j.regsus.2023.05.005
7. Arifuddin Lamusa & Prof. Dr. Ir. Sri Widodo, M.Sc. (2010). Analisis dampak ENSO terhadap efisiensi usahatani dan ketahanan pangan rumahtangga tani di Provinsi Sulawesi Tengah. http://etd.repository.ugm.ac.id/home/detail_pencarian/49438
8. Burliai, A., Burliai, O., Okhrymenko, B., & Zhuravel, R. (2021). Risks of investing in the agricultural sector of Ukraine's economy in the context of modernization of the industry. VUZF Review, 6(4), 128–135. https://doi.org/10.38188/2534-9228.21.4.14
9. Busungu, C. (2023). Past, Present and Future Perspectives of Rice Production in Tanzania. Agricultural Sciences, 14(08), 987–1006. https://doi.org/10.4236/as.2023.148066
10. Cass, A., Gusli, S., & MacLeod, D. A. (1994). Sustainability of soil structure quality in rice paddy—Soya-bean cropping systems in South Sulawesi, Indonesia. Soil and Tillage Research, 31(4), 339–352. https://doi.org/10.1016/0167-1987(94)90040-X
11. Dhamira, A., & Irham, I. (2020). THE IMPACT OF CLIMATIC FACTORS TOWARDS RICE PRODUCTION IN INDONESIA. Agro Ekonomi, 31(1). https://doi.org/10.22146/ae.55153
12. Dorairaj, D., & Govender, N. T. (2023). Rice and paddy industry in Malaysia: Governance and policies, research trends, technology adoption and resilience. Frontiers in Sustainable Food Systems, 7, 1093605. https://doi.org/10.3389/fsufs.2023.1093605
13. Effendy, Antara, M., Muhardi, Pellokila, M. R., & Mulyo, J. H. (2022). Effect of Socio-Economic on Farmers' Decisions in Using Lowland Rice Production Inputs in Indonesia. International Journal of Sustainable Development and Planning, 17(1), 235–242. https://doi.org/10.18280/ijsdp.170123

14. Ermanto, A., Suryanto, A., & Hariyono, D. (2021). Efforts to Improve Productivity of Paddy (Oryza sativa L.) Var. Inpari 30 by Settings of Planting and Different Cropping Patterns. PLANTROPICA: Journal of Agricultural Science, 6(2), 163–173. https://doi.org/10.21776/ub.jpt.2021.006.2.9
15. Gamayanti, N. F., Junaidi, J., Fadjryani, F., & Nur'eni, N. (2023). ANALYSIS OF SPATIAL EFFECTS ON FACTORS AFFECTING RICE PRODUCTION IN CENTRAL SULAWESI USING GEOGRAPHICALLY WEIGHTED PANEL REGRESSION. BAREKENG: Jurnal Ilmu Matematika Dan Terapan, 17(1), 0361–0370. https://doi.org/10.30598/barekengvol17iss1pp0361-0370
16. Habib-ur-Rahman, M., Ahmad, A., Raza, A., Hasnain, M. U., Alharby, H. F., Alzahrani, Y. M., Bamagoos, A. A., Hakeem, K. R., Ahmad, S., Nasim, W., Ali, S., Mansour, F., & El Sabagh, A. (2022). Impact of climate change on agricultural production; Issues, challenges, and opportunities in Asia. Frontiers in Plant Science, 13, 925548. https://doi.org/10.3389/fpls.2022.925548
17. Hafif, B., Kartika, K., Randriani, E., Pitono, J., Gusmaini, G., Ridwan, R., & Nurida, N. (2024). CH4 and N2O emissions and their potential control by rice biomass biochar: The case of continuously flooded paddy fields in Indonesia - A review. One Ecosystem, 9, e109657. https://doi.org/10.3897/oneeco.9.e109657
18. Hussain, Y. (2024). The Impact of Climate Change on Rice Production in Punjab: An Auto Regression Distributed Lag Model. Current Agriculture Research Journal, 12(2), 915–927. https://doi.org/10.12944/CARJ.12.2.33
19. Jankelova, N., Masar, D., & Moricova, S. (2017). Risk factors in the agriculture sector. Agricultural Economics (Zemědělská Ekonomika), 63(6), 247–258. https://doi.org/10.17221/212/2016-AGRICECON
20. Keil, T. (2004). Building External Corporate Venturing Capability*. Journal of Management Studies, 41(5), 799–825. https://doi.org/10.1111/j.1467-6486.2004.00454.x
21. Kicińska, A., & Wikar, J. (2021). Ecological risk associated with agricultural production in soils contaminated by the activities of the metal ore mining and processing industry—Example from southern Poland. Soil and Tillage Research, 205, 104817. https://doi.org/10.1016/j.still.2020.104817
22. Komarek, A. M., De Pinto, A., & Smith, V. H. (2020). A review of types of risks in agriculture: What we know and what we need to know. Agricultural Systems, 178, 102738. https://doi.org/10.1016/j.agsy.2019.102738
23. Mailena, L., Sumedi, Muharam, A., Mardianto, S., & Hanifah, V. W. (2021). The method on measuring utilization index of agricultural technology. IOP Conference Series: Earth and Environmental Science, 892(1), 012049. https://doi.org/10.1088/1755-1315/892/1/012049
24. Midden, C. J. H., Kaiser, F. G., & Teddy McCalley, L. (2007). Technology's Four Roles in Understanding Individuals' Conservation of Natural Resources. Journal of Social Issues, 63(1), 155–174. https://doi.org/10.1111/j.1540-4560.2007.00501.x
25. Mohidem, N. A., Hashim, N., Shamsudin, R., & Che Man, H. (2022). Rice for Food Security: Revisiting Its Production, Diversity, Rice Milling Process and Nutrient Content. Agriculture, 12(6), 741. https://doi.org/10.3390/agriculture12060741
26. Murniati, K., & Mutolib, A. (2020). The impact of climate change on the household food security of upland rice farmers in Sidomulyo, Lampung Province, Indonesia. Biodiversitas Journal of Biological Diversity, 21(8). https://doi.org/10.13057/biodiv/d210809
27. Nasikh, Kamaludin, M., Narmaditya, B. S., Wibowo, A., & Febrianto, I. (2021). Agricultural land resource allocation to develop food crop commodities: Lesson from Indonesia. Heliyon, 7(7), e07520. https://doi.org/10.1016/j.heliyon.2021.e07520
28. Norfahmi, F., Komalawati, K., Juradi, Muh. A., Mardiana, M., & Munier, F. F. (2021). The Identification of Rice Varieties Used in Central Sulawesi. E3S Web of Conferences, 232, 03013. https://doi.org/10.1051/e3sconf/202123203013
29. Rafiuddin, Mollah, A., Risal, M., Musa, Y., Yassi, A., & Dachlan, A. (2021). Growth and production of paddy rice (Oryza sativa L.) in various planting systems and types of liquid organic fertilizers. IOP Conference Series: Earth and Environmental Science, 807(4), 042055. https://doi.org/10.1088/1755-1315/807/4/042055
30. Rauf, R. A., Erny, Damayanti, L., & Malik, S. R. (2023). Food security of lowland rice farmers to support sustainable food development in Parigi Moutong District, Indonesia. IOP Conference Series: Earth and Environmental Science, 1253(1), 012061. https://doi.org/10.1088/1755-1315/1253/1/012061
31. Rusmayandi, G., Indriyani, Hertini, E. S., Harahap, M. A. K., & Nugroho, R. J. (2023). Climate Change, Agricultural Production, Food Security, and Livelihoods of Rural Communities in Rural Districts: A Qualitative Approach. West Science Interdisciplinary Studies, 1(02), 9–17. https://doi.org/10.58812/wsis.v1i02.43
32. Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. World Development, 146, 105599. https://doi.org/10.1016/j.worlddev.2021.105599
33. Saud, S., Wang, D., Fahad, S., Alharby, H. F., Bamagoos, A. A., Mjrashi, A., Alabdallah, N. M., AlZahrani, S. S., AbdElgawad, H., Adnan, M., Sayyed, R. Z., Ali, S., & Hassan, S. (2022). Comprehensive Impacts of Climate Change on Rice Production and Adaptive Strategies in China. Frontiers in Microbiology, 13, 926059. https://doi.org/10.3389/fmicb.2022.926059
34. Septiana, B., Yazid, M., & Hakim, M. M. (2019). ANALYSIS OF FACTORS INFLUENCING THE PRODUCTIVITY OF LOWLAND RICE DURING THE SECOND PLANTING SEASON IN PALEMBANG CITY, INDONESIA. Russian Journal of Agricultural and Socio-Economic Sciences, 86(2), 228–231. https://doi.org/10.18551/rjoas.2019-02.26
35. Silva, J. V., Pede, V. O., Radanielson, A. M., Kodama, W., Duarte, A., De Guia, A. H., Malabayabas, A. J. B., Pustika, A. B., Argosubekti, N., Vithoonjit, D., Hieu, P. T. M., Pame, A. R. P., Singleton, G. R., & Stuart, A. M. (2022). Revisiting yield gaps and the scope for sustainable intensification for irrigated lowland rice in Southeast Asia. Agricultural Systems, 198, 103383. https://doi.org/10.1016/j.agsy.2022.103383
36. SIM, K., Socheat SOU, Chanthy SAM, Phanith CHOU, & Malyne NEANG. (2012). The Impact of Climate Change on Rice Production in Cambodia. NGO Forum on Cambodia. https://doi.org/10.13140/2.1.3464.5122
37. Sitaresmi, T., Hairmansis, A., Widyastuti, Y., Rachmawati, Susanto, U., Wibowo, B. P., Widiastuti, M. L., Rumanti, I. A.,

Suwarno, W. B., & Nugraha, Y. (2023). Advances in the development of rice varieties with better nutritional quality in Indonesia. Journal of Agriculture and Food Research, 12, 100602. https://doi.org/10.1016/j.jafr.2023.100602
38. Sofiyuddin, M., Suyanto, S., Kadir, S., & Dewi, S. (2021). Sustainable land preparation for farmer-managed lowland agriculture in Indonesia. Forest Policy and Economics, 130, 102534. https://doi.org/10.1016/j.forpol.2021.102534
39. Sumarniasih, M. S., Ginting, M. H., & Bhayunagiri, I. B. P. (2022). Evaluation and improvement of rice field quality in Seririt District, Buleleng Regency, Bali Province, Indonesia. Journal of Degraded and Mining Lands Management, 10(1), 3841. https://doi.org/10.15243/jdmlm.2022.101.3841
40. Yuliarso, M. Z., Windirah, N., & Widono, S. (2020). THE IMPLEMENTATION OF INTEGRATED CROPPING CALENDAR ON LOWLAND RICE FARMING IN BENGKULU CITY. Jurnal AGRISEP: Kajian Masalah Sosial Ekonomi Pertanian Dan Agribisnis, 19(2), 407–416. https://doi.org/10.31186/jagrisep.19.2.407-416