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The Relationship Between Climate Change And Tobacco Farmer Resilience In Bojonegoro Regency, Indonesia

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Abstract
Climate change is a global issue that has a significant impact on the agricultural sector, including tobacco commodities in Bojonegoro Regency as the main producer of Virginia tobacco in East Java. This study aims to analyze the relationship between climate change risks and the resilience index of tobacco farmers, with a focus on identifying risk forms, measuring resilience based on five capitals (natural, human, physical, financial, social), and the dominant factors that influence resilience. The research method uses a quantitative explanatory approach through a questionnaire to 436 tobacco farmers in five production center districts (Kepohbaru, Baureno, Kedungadem, Sumberrejo, Kanor), selected by stratified random sampling. Data analysis was carried out using Structural Equation Modeling-Partial Least Squares (SEM-PLS) and mediation tests. The results of the study indicate: climate change risks (managed with the SHARP/FAO approach) have a significant effect on farmer resilience; Productive factors (business efficiency), resilience (ability to survive), and human (adaptive capacity) are positively related to resilience; Social factors (networks, community support) have a negative relationship, indicating that weak social networks have the potential to reduce resilience. The study found that increasing tobacco farmer resilience requires structured interventions that address access to climate information, adaptation training, and strengthening human capital and productivity. Policy implications include the development of a climate early warning system, business diversification, and farmer group-based mentoring to reduce social vulnerability.
Keywords: *Climate change, Farmer Resilience, Tobacco, SHARP, CRI*

INTRODUCTION

Climate change is one of the most pressing global issues today. Its impacts are already being felt across various sectors, including increases in global average temperatures, the frequency of daily and seasonal extreme highs and lows, and increases in some regions (Ulfa, 2018; Nadia Naja, 2024). Sulkan's research found that the increase in the frequency and duration of heat waves and the increase in global surface temperatures are being responded to by global cycles through changes in rainfall patterns during the wet and dry seasons that vary across regions (Mohammad Sulkan, 2020). Simulation results show increased rainfall in equatorial regions, particularly in the Pacific Ocean, resulting in changes in long-term climate parameters that influence climate variability, such as the El Niño-Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and monsoons (Trade et al., 2013).

According to the Meteorology, Climatology, and Geophysics Agency (BMKG), the annual air temperature anomaly as the difference between the air temperature in a particular year and the average annual air temperature for 30 years (the normal period of 19991-2020), shows that from 117 BMKG observation stations, the average air temperature for the 1991-2020 period in Indonesia was 26.7°C and the average annual air temperature for 2024 was 27.5°C, so the average annual anomaly in 2024 was 0.8°C. This condition shows that throughout the observation period from 1981 to 2024 in Indonesia, 2024 was ranked first as the hottest year in Indonesia with an anomaly of 0.8°C (BMKG, 2025).

This condition shows that the impact of climate change is real and will have an impact on the agricultural sector. These impacts include degradation and decline in the quality of land and water resources, agricultural infrastructure, and decreased production and productivity of food crops, which will threaten food security and lead to increased poverty. These changing conditions can also increase the risks of agricultural businesses, including food crops, plantations, livestock, and horticulture. Farmers will be at a loss to cope with climate change due to persistent rainfall and increased pest attacks, resulting in decreased crop production.

One of the impacts felt by agribusinesses, particularly tobacco. Locally, tobacco is a commodity with high economic value (Murdiyati & Basuki, 2011). Tobacco farming can contribute around 40-80% of total farmer income (Purba et al., 2021). At the national level, tobacco farming is a source of state revenue through cigarette excise, foreign exchange, and taxes. It is undeniable that tobacco businesses play a role in providing employment for low-income communities (Rachmat, 2010).

A report from the Central Statistics Agency (BPS) shows that most Indonesian tobacco is produced on the island of Java. East Java is one of the highest tobacco-producing provinces, with a total production of 173,952 tons (BPS, 2024). Within this province, Bojonegoro Regency is a center for tobacco production (Purba et al., 2021). The tobacco produced is the Virginia variety, with a planted area of 15.9 thousand hectares spread across 26 sub-districts (Bhirawa Editorial Team, 2024).

Resilience is the ability of individuals, households, communities, or systems to withstand challenges such as climate change. In the face of unpredictable climate change, resilience is essential for anticipation, adaptation, survival, and recovery (Putri & Danastri, 2024). Simply put, resilience is not only about survival, but also the ability to change and thrive under stressful conditions (Rifky Setya Anugrah, 2024). Therefore, measuring resilience indices is crucial for assessing, monitoring, and evaluating the impacts and risks of climate change. The Climate Resilience Index (CRI), developed by the International Livestock Research Institute (ILRI), FAO, and USAID CGIAR, is a five-dimensional framework comprising natural capital, physical capital, financial capital, social capital, and human capital (MSC, 2023).

Research on the risks of climate change to tobacco farmers is rare. Furthermore, there are gaps in research conducted by researchers, particularly in terms of research locations and variables studied. Based on research conducted by (Alkalah, 2016) entitled "Analysis of the Effects of Weather on the Quality of Various Types of Tobacco," there is a difference from the researcher's research, namely the research location, which is in Jember Regency. Another study conducted by (Putri, 2012) entitled "Adaptation Strategy for the Impact of Climate Change on the Tobacco Farming Sector (Case Study: Bulu District, Temanggung)" differs from the researcher's research, namely the variables of climate change impacts and the research location, which was conducted in Temanggung. Another study conducted by Dewi, entitled "The Relationship between Climate Change and Tobacco Production and the Level of Livelihood Vulnerability of Farmers in Klaten Regency," differs from the researcher's research, namely the additional variables related to the level of livelihood vulnerability of farmers and the research location, which was conducted in Klaten Regency (Dewi, 2017).

Based on the data presented and the conditions, climate change has a significant impact on tobacco production in East Java. Various factors such as rainfall, temperature, and land location significantly influence tobacco productivity levels. Therefore, tobacco farmers need to change their practices and adapt by adjusting planting times to support food security and improve their economic well-being, through ongoing research and monitoring. However, climate adaptation policies in the agricultural sector, particularly for commodities other than rice, such as tobacco, are still minimal. This highlights the need for local data and research to support targeted policy formulation. Based on this problem description, this study focuses on analyzing the relationship between climate change risks and tobacco farmers in Bojonegoro Regency. Based on the background described, the research question is: What is the relationship between climate change risks and the resilience index of tobacco farmers in Bojonegoro Regency?

Theoretical Framework

Scientists have discussed the issue of climate change, focusing on global warming triggered by human activities. Human actions that increase greenhouse gas emissions into the atmosphere are making the earth warmer. The increase in Earth's surface temperature due to global warming is estimated at around 5 degrees Celsius per year, which can trigger global climate change (Samidjo & Suharso, 2017). Climate change certainly has effects or impacts on life, such as increasing temperatures, increasing global temperatures that will cause the poles to melt, rising sea levels, and increasing the frequency of disasters such as floods, tsunamis, storms, and others. Climate change will also result in unpredictable weather changes, the spread of disease, and increased ocean acidity, which will ultimately damage underwater ecosystems (Rizky et al., 2022).

In the agricultural sector, climate change has a significant impact, necessitating sustainable climate risk management. Climate risk management in the agricultural sector is a crucial approach to addressing the impacts of climate change on the sustainability of agricultural systems. According to the IPCC (2019), climate change has increased uncertainty in weather patterns, thereby affecting agricultural productivity. Therefore, to address climate change issues, a comprehensive and sustainable approach to climate change management strategies and implementation in the agricultural sector is needed to mitigate the impacts of climate change on food production (Harahap et al., 2024).

Climate Change Risk

Risk in the context of climate change refers to the potential for adverse impacts on human and ecological systems, taking into account the diversity of values and goals associated with those systems. Climate change risks can originate from two main sources: risks arising from the direct impacts of climate change and risks arising from human responses to climate change (IPCC, 2021).

Risks arising from the direct impacts of climate change result from the dynamic interaction between climate hazards (such as droughts, floods, and storms), the level of human or ecosystem exposure to hazards (exposure), and the system's vulnerability to those impacts. These three elements are influenced by uncertainty in magnitude, frequency, and changes resulting from socioeconomic factors and human decisions over time. The agricultural sector is particularly vulnerable to climate change. Climate change negatively impacts several aspects of life. The impacts of climate change tend to be detrimental because they cause changes to agroecology and people's livelihoods (Kurniawan & Arisurya, 2021). Some of the impacts of climate change on agriculture include:

In the agricultural sector, the concept of risk can refer to a possibility that could cause losses, one of which is a decrease in food crop production (Nuraisah & Kusumo, 2019). Extreme climate phenomena such as El Niño and La Niña also play a significant role in reducing food crop production. Furthermore, climate change triggers an increase in the frequency of natural disasters, such as floods, droughts, and pest and disease attacks, which can directly and indirectly impact agricultural productivity and increase the risk of crop failure. Unstable weather patterns, such as erratic rainfall and drought, can disrupt crop and harvest cycles, thereby reducing production yields (Rozci, 2023). Climate change can also affect the distribution and availability of natural resources that are the basis for food production, such as water and land. Deteriorating soil quality due to erosion and soil degradation can also reduce agricultural productivity (Anjani et al., 2024). Climate change can lead to crop failure due to prolonged droughts and flooding, which can damage food crops. If crops survive, the resulting harvest will be suboptimal and suffer from quality defects (Rozci, 2023).

METHOD

This research section uses a quantitative approach with an explanatory research approach. The data collection method used was a questionnaire. The study was conducted from April to June 2025. The research location was Bojonegoro Regency. The study population was all tobacco farmers in the Bojonegoro Regency area.

Inclusion criteria: a) residents of Bojonegoro Regency in five sub-districts: Kepohbaru, Baureno, Kedungadem, Sumberrejo, and Kanor; b) willingness to participate as respondents; and b) complete the questionnaire. This study employed a stratified random sampling technique based on the largest tobacco-producing sub-districts. This technique allows each member of the population an equal chance of being selected, resulting in a representative sample of the population (Sugiyono, 2018).

Research Sample

The sample size in this study was calculated using the Solvin formula =

n = 395.5 = 396

Note:

n = Number of samples

N = Population

E = Maximum tolerable margin of error 0.05 (5%)
To anticipate non-compliance or dropout of respondents, the sample size was increased to: N = 396 + (10% x 396) = 396 + 40 n = 436, so the minimum sample size required for this study was 436 respondents.

Research Variables and Instruments

Independent variable: The independent variable in this study is climate change risk, as measured using the SHARP (social, human, adaptive, resilience, and productive) approach issued by the FAO. Dependent variable: The dependent variable in this study is the level of resilience of tobacco farmers, as measured using the CRI approach with five indicators: natural, human, physical, social, and financial.

The climate change risk questionnaire consists of five aspects: a) social relationships, networks, and access to information; b) capacity, skills, and access to services; c) adaptation to conditions; d) resilience to threats; and e) efficiency, sustainability, and agricultural yields. The resilience questionnaire consists of five aspects: a) natural aspects (irrigation access, soil quality, location); b) human aspects (abilities and skills); c) physical aspects (tools, access, facilities); d) financial aspects (savings, loans, other sources of income); and e) social aspects (participation, discussion, and social support).

Primary data collection was conducted through direct observation and interviews using a questionnaire to obtain several questionnaire items from tobacco farmers in Bojonegoro Regency. Furthermore, for risk management and farmer resilience, a focus group discussion was conducted with several key figures who served as in-depth interviewees to strengthen the research findings.

Next process was carried out using the following stages: a) Editing: The researcher rechecked the completeness of the data to minimize missing data or inappropriate answers; b) Cleaning: The researcher checked the data for errors, such as completeness, consistency, and validity of the answers; c) Coding: The researcher converted the letter-based data in the questionnaire into numerical form for easier analysis; and d) Tabulating: The data was processed by entering it into the SPSS program for data analysis.

Data Analysis Techniques

The data analysis technique used quantitative analysis methods. Quantitative analysis is a method for examining data in numerical form and analyzing it statistically using descriptive statistics. Univariate analysis is used to specifically describe the characteristics of each variable, whether independent, intermediate, or dependent, which will be presented in frequency tables and percentages. Quantitative data analysis was used to analyze the relationship between the influence of climate change risks and farmer resilience, with the aim of examining the relationships between variables.

RESULTS AND DISCUSSION

Based on Age Distribution of Tobacco Farmer Respondents in Bojonegoro Regency (Figure 1), it shows that the majority of respondents are aged 20-44, with 415 respondents (94.3%). Meanwhile, the age group with the smallest number of respondents is 10-19, with 1 respondent (0.2%). Based on Gender Distribution of Tobacco Farmer Respondents in Bojonegoro Regency (Figure 2), it shows that the majority of respondents were male (360 respondents (81.8%), while 80 respondents (18.2%) were female. Based on Distribution of Education Levels of Tobacco Farmer Respondents in Bojonegoro Regency (Figure 3), it shows that the majority of respondents had a D4/S1 education level, with 187 respondents (42.5%). Meanwhile, the lowest level of education was elementary school/Islamic elementary school/equivalent, with 4 respondents (0.9%). Based on Distribution of Years of Employment of Tobacco Farmer Respondents in Bojonegoro Regency (Figure 4), it shows that the majority of respondents (230 respondents) (52.3%) had worked as farmers for ≥10 years. Meanwhile, the fewest respondents were in the 7-9 years group, with 38 respondents (8.6%).

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Gender	Number (n)	Persentage (%)
Male	360	81,80%
Female	80	18,20%
Total	440	100%

Figure 1

Age	Number (n)	Percentage (%)
10-19 year (Adolescents)	1	0,20%
20-44 Year (Adult)	415	94,30%
45-60 Year (Elderly)	24	5,50%
Total	440	100%

Figure 2

Figure 3

Education Level	Number (n)	Persentage (%)
No Education	6	1,40%
Elementary School/Islamic Elementary School/Equivalent	4	0,90%
Junior High School/Islamic Junior High School/Equivalent	53	12%
Senior High School/Islamic Senior High School/Equivalent	164	37,30%
Diploma I	0	0%
Diploma II	1	0,20%
Diploma III	20	4,50%
D4/S1	187	42,50%
S2/M	5	1,10%
Total	440	100%

Figure 4

Year of Employment	Number (n)	Percentage (%)
< 1 Year	53	12%
1-3 Year	56	12,70%
4-6 Year	63	14,30%
7-9 Year	38	8,60%
≥ 10 Year	230	52,30%
Total	440	100%

Results of the Analysis of the Relationship between Climate Change Risk and Farmer Resilience

The outer model is part of the SEM-PLS analysis model used to evaluate the validity and reliability of indicators in representing latent variables. The outer model explains the relationship between measurable indicators and latent constructs, using both reflective and formative models. Evaluation in this analysis includes tests of convergent validity, discriminant validity, and construct reliability. The following is a graphic depicting the results of the outer model analysis for each indicator (Figure 5).

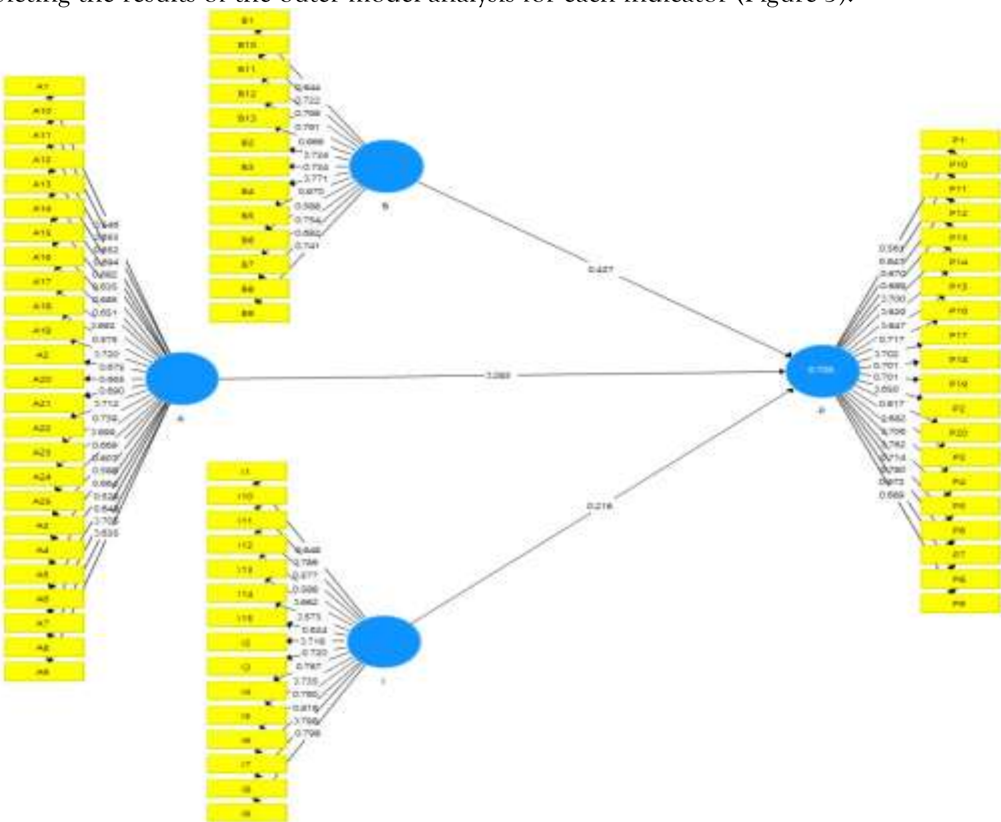

Figure 5. Results of the Analysis of the Relationship between Climate Change Risk and Farmer Resilience

The analysis found that several aspects of climate change risk significantly influence tobacco farmer resilience. Social variables have a significant direct effect on farmer resilience, although the coefficient is negative, indicating that increased perceptions of social risks (such as lack of community support or social networks) tend to decrease farmer resilience. Meanwhile, resilience and productivity variables exhibit positive and significant effects on farmer resilience.

This suggests that personal resilience and production efficiency play a key role in maintaining tobacco farmers' sustainability in the face of climate change. Furthermore, human variables (capacity and skills) also have a positive and significant effect. These findings suggest that increasing individual capacity to understand climate risks and manage resources can improve long-term resilience. In Indonesia, Pramudia et al. (2021) reported a similar finding among horticultural farmers in Central Java, where technological adaptation and business diversification were key to farmer resilience to climate anomalies.

These findings align with a study by Etwire (Alidu et al., 2022) in Climate and Development, which states that farmer resilience to climate change is significantly influenced by social capacity, adaptation experience, and access to technology and information. According to Adzawla et al., 2024, in Ghana, social variables such as farmer group membership, as well as human variables such as training and climate knowledge, contribute significantly to drought resilience. Furthermore, they asserted that high perceptions of climate risk can reduce motivation to adopt innovations if not accompanied by institutional support. In Indonesia, Pramudia et al., 2021 also reported a similar finding among horticultural farmers in Central Java, where technological adaptation and business diversification were key to farmer resilience to climate anomalies.

The analysis showed that social, productive, and resilience factors significantly influenced farmer resilience through mediation of information access and adaptation strategies. This suggests that the negative effects of social factors on resilience can be mitigated if farmers have access to information and are able to adapt appropriately. This reinforces the importance of weather-information-based interventions and climate training to bridge social structural weaknesses. A study by Harvey et al. (2021) in Agricultural Systems showed that timely information delivery, particularly through digital channels and local extension workers, can alter risk perceptions and promote systemic resilience.

Climate change risk has a significant relationship with the resilience of tobacco farmers in Bojonegoro Regency. Based on the model and F-square value, adaptation strategies and access to information significantly contribute to strengthening the relationship between climate risk and resilience. However, it is important to note that not all risk dimensions have a positive influence; for example, the adaptive dimension showed a negative, insignificant direct effect on resilience, although its indirect effect through adaptation strategies was significant. This suggests that without a structured strategy, farmers' adaptive capacity does not automatically impact resilience.

CONCLUSION

Climate change risk factors have a significant relationship with the resilience of tobacco farmers in Bojonegoro Regency. Human, productive, and resilience factors are positively related. However, social factors have a negative relationship, and adaptive factors have no direct relationship except through adaptation strategies. These findings confirm that adaptive capacity without structured strategies is insufficient to effectively increase farmer resilience.

Furthermore, increasing tobacco farmer resilience requires structured interventions that provide access to climate information, adaptation training, and strengthen human capital and productivity. Policy implications include the development of climate early warning systems, business diversification, and farmer group-based mentoring to reduce social vulnerability.

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SHORT-BIO

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