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MORALITY BEFORE KNOWLEDGE

Building resilience in Indonesian agrarian communities: Adaptation strategies and institutional barriers in response to climate change

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ABSTRACT

Background: Climate change has become a real threat to the agricultural sector in Indonesia, with significant impacts on productivity, food security, and the welfare of farmers. Rising global temperatures, shifting rainfall patterns, and extreme climate events have increased the risk of crop failure and reduced the adaptive capacity of agrarian communities. This study aims to examine the adaptation and resilience strategies of agrarian communities in responding to climate change, as well as to identify the structural and institutional barriers they face. **Methods:** The research employs a qualitative approach with a case study design in several climate-vulnerable areas, including Wonosobo, Bima, and Maros. Data was collected through participatory observations, in-depth interviews, focus group discussions, and document analysis. The Sustainable Livelihood Framework is used to analyze five types of capital that influence farmers' adaptive capacity: natural, human, social, physical, and financial capital. Thematic analysis is applied to explore narrative patterns of farmers' adaptation to climate change. **Findings:** The findings of this research are expected to contribute to the formulation of community-based adaptation policies and the strengthening of climate-resilient agricultural systems. **Conclusion**: This study highlights the significant impact of climate change on agricultural livelihoods in Indonesia, while also revealing the adaptive resilience strategies developed by communities through various livelihood assets. **Novelty/Originality of this article:** This study also highlights the importance of institutional support, adaptive technologies, and the preservation of local wisdom as integral components of strategies to enhance the resilience of agrarian communities in Indonesia.

KEYWORDS: agrarian communities; climate change; climate policy; local wisdom; resilience; sustainable livelihood

1. Introduction

Climate change has become one of the most urgent and complex environmental issues in human history. The Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment Report (AR6) (2022), stated that the global average temperature has increased by approximately 1.1°C compared to the pre-industrial period (1850–1900). Temperature projections indicate a further rise of up to 1.5°C by the mid-21st century if greenhouse gas emissions are not drastically reduced. This temperature increase has triggered various changes in the global climate system, including sea-level rise, polar ice melt, and the increasing frequency of extreme weather events such as floods, droughts, and heatwaves.

The impacts of climate change are not only physical but also socio-economic. Rising sea levels, for example, threaten coastal areas and small islands, including Indonesia's archipelagic regions, which are highly vulnerable to seawater intrusion and coastal erosion

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(Warren et al., 2006). Changes in rainfall patterns have led to crop failures, infrastructure damage, and disruptions to the livelihoods of communities, particularly those dependent on agriculture and fisheries. Global climate phenomena such as the El Niño Southern Oscillation (ENSO) have also become increasingly unpredictable due to climate change. ENSO affects rainfall patterns worldwide and has significant implications for food production systems. In this context, Indonesia, as a tropical country, is highly vulnerable to ENSO anomalies, which can cause prolonged droughts or extreme rainfall, disrupt planting cycles, and increase the risk of crop failure (Cubasch & Meehl, 2001). anomalies, which can cause prolonged droughts or extreme rainfall, disrupt planting cycles, and increase the risk of crop failure (Cubasch & Meehl, 2001).

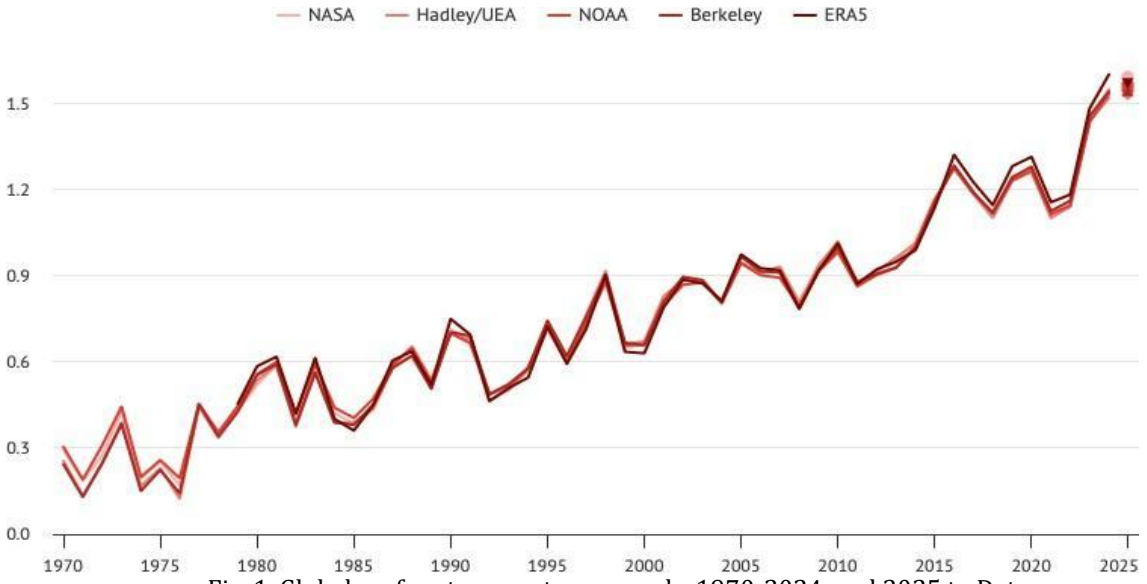

Fig. 1. Global surface temperature records, 1970-2024, and 2025 to Date (Hausfather, 2025)

As an agrarian country, Indonesia relies heavily on the agricultural sector as a primary source of income and national food security. Data from Statistics Indonesia (BPS, 2023) indicates that approximately 29% of the national workforce is employed in the agricultural sector. However, this sector is also among the most vulnerable to climate change. High dependence on rainfall, inadequate irrigation infrastructure, and limited access to adaptive technologies make agricultural systems highly susceptible to climatic fluctuations. Several regions, such as Central Java, East Nusa Tenggara, and South Sulawesi, face a 20–30% risk of crop failure due to unpredictable climate patterns (BMKG, 2022). Uncertainty in planting seasons, increased drought intensity, and the emergence of crop pests and diseases due to temperature and humidity changes present increasingly complex challenges for farmers throughout Indonesia.

The impact of climate change on agricultural productivity is further corroborated by scientific studies. Lobell et al. (2011) state that a 1°C increase in temperature can reduce rice and maize yields by 3–5% in tropical regions. In the long term, this condition has the potential to trigger food crises, increase the prices of agricultural commodities, and exacerbate poverty in rural areas. In addition to being one of the most affected sectors, agriculture also contributes significantly to global greenhouse gas emissions.

According to a report by the Food and Agriculture Organization (FAO, 2019), the global agricultural sector accounts for approximately 24% of total greenhouse gas emissions, equivalent to 5 billion metric tons of CO_2 equivalent in 2017. These emissions primarily result from livestock enteric fermentation, nitrogen fertilizer use, biomass burning, and land-use change. Indonesia alone contributed around 181 million metric tons of CO_2 equivalent from the agricultural sector during the 2005–2017 period, or about 3% of total global agricultural emissions (FAO, 2019).

Moreover, Indonesia's agricultural sector has shown a consistent upward trend in

greenhouse gas emissions, with an average annual growth of 1,435,634 tons of CO_2 equivalent (Utomo, 2016). These emissions stem from factors such as increases in cattle populations, maize and soybean production, and intensive farming practices that rely heavily on chemical inputs. Land conversion and agricultural land expansion activities also contribute to deforestation and land degradation, further exacerbating climate change. Deforestation in Kalimantan, Sumatra, and Papua, for instance, is often driven by land clearing for oil palm plantations and food crop cultivation (Margono et al., 2014). A study by Austin et al. (2019) found that between 2001 and 2016, approximately 23% of deforestation in Indonesia was directly linked to oil palm expansion.

Additionally, according to Forest Watch Indonesia (2022), land-use conversion for agriculture remains the primary driver of natural forest loss outside protected and conservation forest areas. Furthermore, land-clearing practices using burning methods, still common in both small-scale and industrial agricultural systems, contribute large amounts of carbon emissions and trigger annual forest fire crises, particularly in peatland areas (Tacconi, 2016). These practices not only worsen global climate change through greenhouse gas emissions but also diminish ecosystems' capacity to absorb carbon naturally, thereby lowering climate resilience at both local and national levels.

In addressing the challenges posed by climate change, the concept of resilience is crucial in understanding how agrarian communities can survive and adapt to ongoing changes. Resilience is defined as the ability of individuals, communities, or socio-ecological systems to withstand shocks, adapt, and transform in response to environmental and social pressures (Bollettino et al., 2017). Furthermore, Folke et al. (2010) emphasize that resilience is not merely about returning to the previous state after a shock but also about the capacity to learn, innovate, and transition towards a more sustainable system. Meanwhile, Adger (2000) highlights the social dimensions of resilience, noting that adaptive capacity is greatly influenced by social factors such as social networks, local institutions, and access to resources.

In the context of climate change, the resilience of agrarian communities is essential because these groups often occupy the most vulnerable positions. Their level of resilience is determined by their ability to access climate information, adopt adaptive agricultural technologies, and rely on social capital that enables cooperation within the community (Tanner et al., 2015). Therefore, strengthening adaptive capacity must be integrated by enhancing local institutional structures and mainstreaming local knowledge in climate change policies.

According to the sustainable livelihood framework developed by Ellis (2000), the resilience of agrarian communities depends on five types of capital: (1) natural capital, such as land, water, biodiversity, and a stable climate; (2) human capital, including knowledge, skills, and public health; (3) social capital, encompassing social networks, local institutions, and customary norms; (4) physical capital, involving agricultural infrastructure, irrigation systems, tools, and technologies; and (5) financial capital, including savings, access to credit, and income diversification.

A study in East Kalimantan by Amalia (2015) found that ecological changes due to deforestation and land-use conversion affect farmers' resilience in maintaining their livelihoods. In this region, the loss of forests as a source of natural capital has also reduced farmers' adaptive capacity to climate change and natural disasters. This is consistent with the findings of Dewi et al. (2017), who stressed that the conversion of forest areas into large-scale agricultural and plantation land leads to ecosystem degradation and reduces the diversification of local livelihood sources. Additionally, research by Lele et al. (2013) asserts that dependence on single-production systems (monocultures) due to land-use change increases farmers' vulnerability to climate disruptions such as droughts and floods. These impacts become even more significant given that many agrarian communities lack access to climate information, adaptive technology, and adequate institutional support (Kusters et al., 2017).

Various efforts have been made to strengthen farmers' resilience through both technological interventions and the revitalization of local wisdom. The concept of climate-

smart agriculture (CSA), introduced by the FAO (2013, 2022), emphasizes three main pillars: increasing productivity, enhancing resilience to climate change, and reducing greenhouse gas emissions from agricultural activities. Examples of CSA implementation in Indonesia include: (1) the use of drought- and flood- tolerant rice varieties, (2) drip irrigation and precision farming systems, (3) integrating crop and livestock farming for resource efficiency, and (4) community-based climate early warning systems (climate information services).

Moreover, traditional practices based on local wisdom, such as subak in Bali, shifting cultivation in Kalimantan, and sasi laut in Maluku, demonstrate that local communities possess adaptive strategies that have been tested over generations in managing natural resources sustainably (Dove, 1993). However, the effectiveness of these strategies is often constrained by a lack of policy support, limited access to technology and climate information, and weak inter-sectoral coordination. In many areas, limited education and institutional capacity also hinder the adoption of adaptive technologies (Nelson et al., 2021).

Building resilience in the agricultural sector requires comprehensive, cross-sectoral policy support. The Government of Indonesia has formulated various policies, such as the National Action Plan for Climate Change Adaptation/*Rencana Aksi Nasional Adaptasi Perubahan Iklim* (RAN-API), but its implementation at the local level has often been ineffective due to weak inter-ministerial coordination, limited climate data accessible to farmers, and insufficient institutional capacity in the regions. Strategic recommendations that should be considered include strengthening climate data-based extension systems, providing incentives for farmers practicing sustainable agriculture, developing climate risk-based agricultural insurance schemes, increasing investments in research and development for climate-resilient crop varieties, and mainstreaming local wisdom in adaptation planning.

Given the complexity of climate change challenges to the agricultural sector and the livelihoods of agrarian communities, studies on adaptation actions and resilience are increasingly urgent. A comprehensive understanding of the factors influencing farmers' resilience—social, economic, and ecological—can assist in designing more targeted and effective policy interventions. Based on these issues, this study aims to examine the resilience and adaptation strategies of agrarian communities to climate change, identify structural and institutional barriers they face, and formulate policy recommendations to strengthen long-term agricultural sector resilience.

2. Methods

This study employs a descriptive qualitative approach with document analysis as the primary strategy to describe and analyze the resilience and adaptive actions of agrarian communities in response to climate change in Indonesia. A qualitative approach was selected as it enables the exploration of meanings, social dynamics, and adaptive responses of agrarian communities to climate change through the examination of secondary data from various credible sources. According to Creswell (2013), qualitative research focuses on understanding the social context and the meanings behind the phenomena being studied, making it highly relevant for examining complex and contextual issues such as climate change, particularly within the agricultural sector in Indonesia.

The research locations were purposively determined based on the vulnerability of the areas to climate change and the significance of the agricultural sector to local livelihoods. The areas considered in this study include Wonosobo Regency (Central Java), Bima Regency (West Nusa Tenggara), and Maros Regency (South Sulawesi). These areas represent variations in agroecological characteristics and levels of exposure to extreme climate phenomena such as droughts, floods, and shifts in planting seasons.The data in this study are derived from secondary sources, including documentation, official reports, statistical publications, and relevant academic literature. The data sources used in this research are presented in Table 1.

Table 1. Data source

No.	Data Source	Type of Data	Description
1.	Regional Medium-Term Development Plan of Regencies/Cities	Regional development planning documents	Presents development priorities in the agricultural sector and related sectors
2.	Strategic Plan for Agricultural Service Agencies	Strategic plans of Regional Apparatus Organizations	Programs, work plans, and targets for agricultural development and climate adaptation
3.	Reports from the Indonesian Agency for Meteorological, Climatological and Geophysics	Climate and weather data	Rainfall, temperature, drought events, and climate anomalies
4.	Publications from the Central Bureau of Statistics	Agricultural production, employment, and welfare statistics	Agricultural production, labor force, farmer welfare index, and poverty rates
5.	National Action Plan for Climate Change Adaptation	National policies on climate change adaptation	National strategy documents, adaptation program priorities, and policy directions
6.	Indexed national and international scientific journals	Empirical and conceptual studies	Research findings on agrarian resilience and climate change adaptation

2.1 Data collection and analysis procedures

The data collection procedures in this study were conducted through a comprehensive documentary study approach, which involved systematically tracing, gathering, and analyzing official documents, statistical data, reports, and relevant academic literature. This method was chosen to obtain a multi- dimensional understanding of climate change impacts, agrarian community resilience, and policy responses within the Indonesian context. The documentary sources were selected based on a set of credibility and relevance criteria to ensure the quality and reliability of the information utilized. The criteria included: (1) documents published within the last ten years (2014–2024) to guarantee data currency and relevance to recent climate trends and policy developments; (2) official issuance by national and regional government institutions such as the Meteorology, Climatology, and Geophysics Agency/*Badan Meteorologi, Klimatologi, dan Geofisika* (BMKG), Central Statistics Agency/*Badan Pusat Statistika* (BPS), and the Ministry of Environment and Forestry; (3) scholarly publications indexed in reputable national and international databases, such as SINTA and Scopus; and (4) regional government planning documents, such as Regional Medium-Term Development Plan/*Rencana Pembangunan Jangka Menengah Daerah* (RPJMD) and Strategic Plans of Agricultural Service Agencies/*Rencana Strategis Dinas Pertanian*, officially published on government websites and accessible through public records.

To enhance the rigor of the document analysis, data analysis process applied qualitative content analysis, a well-suited method for systematically interpreting textual data to identify patterns, themes, and interrelationships among variables. The analysis was carried out through several interrelated stages, The analysis in this research was conducted through several interrelated stages to capture the complexity and interrelationships among variables. The first stage was data reduction, which involved reviewing all collected documents and identifying information directly relevant to the research focus. Data were sorted, coded, and selected according to the core themes—climate change impacts on agriculture, agrarian livelihoods, adaptation strategies, and policy interventions—while irrelevant or redundant information was excluded to maintain analytical clarity. The second stage was data categorization, where relevant data were classified into both predetermined and emergent thematic categories. These categories included climate change impacts (such as temperature changes, rainfall patterns, drought frequency, and pest outbreaks), agrarian community resilience (adaptive capacities, livelihood diversification strategies, and

indigenous knowledge practices), government policies and institutional responses (adaptation programs, risk reduction strategies, and climate action plans), and structural barriers and challenges (socio-economic inequalities, access to resources, market limitations, and policy implementation gaps). The third stage was interpretation and narrative construction, in which categorized data were interpreted to reveal underlying meanings, causal relationships, and socio-political contexts that shape agrarian communities' resilience to climate change. A comparative analysis across sources and regions was also conducted to highlight similarities, differences, and distinctive regional patterns. This step enabled the construction of a descriptive and explanatory narrative that reflects the complex, multi-layered dynamics of climate vulnerability and adaptive responses in agrarian areas of Indonesia. By employing document studies and content analysis, this research ensures comprehensive, credible, and contextually grounded study while contributing to more accurate, responsive, and regionally relevant policy recommendations to strengthen the resilience of agrarian communities in the face of climate change.

2.2 Analytical framework

This study employs the Sustainable Livelihood Framework (SLF) (Ellis, 2000) as an analytical tool to examine the resilience of agrarian communities in responding to climate change impacts. The SLF provides a comprehensive and holistic framework that facilitates the analysis of how rural households mobilize and manage various types of livelihood assets or 'capitals' to sustain their livelihoods under conditions of environmental, economic, and social stress. In this study, the framework is operationalized through the assessment of five core livelihood capitals: natural, human, social, physical, and financial capital. Each capital represents a set of resources, capabilities, and relationships that collectively determine the adaptive capacity and resilience of agrarian communities.

The rationale for adopting the SLF lies in its multidimensional perspective on livelihoods, recognizing that vulnerability to climate change is not solely determined by environmental factors, but is deeply intertwined with socio-economic conditions, institutional support, and the availability of livelihood resources. The SLF also emphasizes the dynamic interactions between different types of capital and how they are mediated by policies, institutions, and processes at various levels, from local to national. In the context of this study, each livelihood capital is assessed through a set of operational indicators specifically adapted to the agrarian settings of Wonosobo, Bima, and Maros Regencies**.** These indicators were identified through a review of relevant literature, government policy documents, and empirical studies on climate resilience and rural livelihoods in Indonesia. Table 2 presents the classification of the five livelihood capitals along with the corresponding indicators used for data analysis:

Table 2. Livelihood capitals and indicators for assessing agrarian community resilience

No.	Livelihood Capital	Indicators in the Study
1.	Natural Capital	1. Availability of productive agricultural land 2. Access to water resources for irrigation 3. Use of climate-resilient crop varieties 4. Implementation of land conservation practices
2.	Human Capital	1. Level of farmers' knowledge of climate risks 2. Participation in climate-related training and extension programs 3. Access to early weather warning systems 4. Application of sustainable farming techniques
3.	Social Capital	1. Existence of farmer groups and cooperatives 2. Strength of mutual cooperation (gotong royong) practices 3. Participation in community-based adaptation initiatives 4. Functionality of local agricultural networks
4.	Physical Capital	1. Availability of adaptive agricultural infrastructure (irrigation, storage, access roads)

		2. Access to farming equipment and tools 3. Coverage of disaster-resilient facilities (e.g. flood protection) 4. Condition of market access infrastructure
5.	Financial Capital	1. Household income diversification 2. Access to microcredit or agricultural financing schemes 3. Availability of agricultural insurance 4. Engagement in alternative economic activities

By applying these indicators, the study aims to identify patterns of vulnerability and adaptive strategies within agrarian communities. It also evaluates how existing livelihood capitals contribute to enhancing community resilience against climate-induced risks. Additionally, the SLF framework allows for a comparative analysis across the three study areas to highlight context-specific challenges and opportunities for strengthening livelihood security amid increasing climate uncertainties.

3. Results and Discussions

3.1 The impact of climate change on agrarian livelihood systems

Climate change has become a determining factor affecting the stability of agrarian ecosystems in Indonesia. Document analysis indicates that the increase in average temperatures and changes in rainfall patterns have significantly disrupted food production systems and the sustainability of rural livelihoods. According to the Indonesian Meteorological, Climatological, and Geophysical Agency (BMKG, 2022), a surface temperature increase of 0.18°C per decade has triggered a rise in the frequency of extreme weather events such as droughts, floods, and pest outbreaks.

In Wonosobo Regency, the shifting rainy season has directly impacted the planting cycles of rice, potatoes, and cabbage, which are the region's three primary commodities. Farmers have faced planting and harvesting schedule uncertainties, affecting both the quality and quantity of agricultural yields. A similar phenomenon occurred in Bima Regency, where drought lasting over three months in 2022 resulted in a 30% decline in maize production and crop failure in several horticultural commodities (Rencana Strategis Dinas Pertanian NTB, 2023).

Table 3. Impact of climate change on agricultural production in selected Indonesian regions

No.	Region	Climate Event	Impact on Agriculture	Source
1.	Wonosobo Regency	Shifting rainy season	Disrupted planting cycles of rice, potatoes, and cabbage	BMKG, 2022
2.	Bima Regency	Prolonged drought	Significant decline in Maize Production and crop failures	USAID ERAT, 2023
3.	Maros regency	Extreme rainfall	Flooded over 800 hectares of rice fields; damaged infrastructure	BMKG, 2023

Meanwhile, in Maros, extreme rainfall at the beginning of 2023 caused floods that damaged over 800 hectares of productive rice fields. Beyond reducing rice production, these floods also destroyed irrigation infrastructure and farm access roads, further hampering the distribution of harvested crops to markets. These conditions reinforce the findings of Cubasch & Meehl (2001) and Lobell et al. (2011), which emphasize the vulnerability of the agricultural sector in tropical regions due to global climate anomalies such as the El Niño Southern Oscillation (ENSO) and increasing annual average temperatures. This data underscores the pressing need for adaptive strategies to mitigate the adverse effects of climate change on Indonesia's agricultural sector.

3.2 Patterns of agrarian resilience adaptation strategies

Various forms of adaptation have been undertaken by agrarian communities in the

three study areas in response to the increasing climate uncertainty. Based on the analysis of documents such as the National Action Plan for Climate Change Adaptation/*Rencana Aksi Nasional Adaptasi Perubahan Iklim* (RAN-API), Regional Medium-Term Development Plan/*Rencana Pembangunan Jangka Menengah Daerah*, and the Strategic Plans/*Rencana Strategis* of Agricultural Offices in each region, the adaptation strategies implemented by farmers can be classified into five livelihood capital types as outlined in the Sustainable Livelihood Framework (Ellis, 2000).

Tabel 4. Climate change adaptation strategies by agrarian communities based on the five livelihood capitals

No	Livelhond Capital	Adaptation Strategy	Location	Reference
1	Natural Capital	Cultivation of flood tolerant rice verletes Crop diversification (sorghum, mungbean) Land conservation (terraching, reforestation)	All location	RAN- PI (2021), Agriculture Office trategic Plan (2023)
2	Human Capital	Training in water management and organic farming techniques Community-based early weather warning systems	All location	FAO (2023) BMKG (2022)
3	Social Capital	Community cooperation in irrigation systems Solar-poered water pumps Water-saving ar	All location	Pretty (2003), RPJMD Documents
4	Physical Capital	Development of microirrigation systems Solar-powered water pumps Water-saving agricultural equipment	All location	Nelson et. al (2021)
5	Financial Capital	Income diversification thorugh livestock, handicrafts, and services Limited access to People's Business Credit (KUR) Absence of climate risk-based agricultural insurances schemes	All location	Oxfam (2020), RANPI (2021)

First, in terms of natural capital, agrarian communities in Wonosobo have started cultivating flood- tolerant rice varieties to cope with increasing rainfall intensity. In Bima, farmers have adopted crop diversification by developing sorghum and mung bean as alternative local food commodities more resilient to drought conditions. Meanwhile, in Maros, land conservation efforts have been carried out through the implementation of terracing systems and reforestation in upstream river areas as part of a flood risk mitigation strategy. Consistent with the agroecology concept, crop diversification has proven effective in enhancing the resilience of agrarian ecosystems by increasing biodiversity.

Second, in the dimension of human capital, both individual and collective capacities within agrarian communities to comprehend climate risks are pivotal in fostering resilience. Various training programs on water management, early weather warning systems, and organic farming techniques have been introduced through farmer groups and community-based agricultural extension services. According to the Food and Agriculture Organization (2022), enhancing farmers' capacity to utilize climate information can reduce the risk of crop failure by up to 40%.

Third, concerning social capital, the strong tradition of mutual cooperation (*gotong royong*) in rural areas is manifested in activities such as irrigation channel repairs, provision of high-quality seeds, and the establishment of agribusiness cooperatives, particularly in Wonosobo and Maros. In Bima, community-based seed rotation systems and collective savings groups have emerged as effective social adaptation practices that strengthen solidarity networks among farmers. As explained by Pretty (2003), the existence of local social networks plays a crucial role in enhancing the adaptive capacity of farming

communities in climate-vulnerable regions.

Fourth, in terms of physical capital, regional governments in the three study areas have allocated budgets for the development of adaptive agricultural infrastructure, such as micro-irrigation systems and the provision of water-efficient farming equipment, including drip irrigation systems and solar- powered pumps. However, the coverage of these programs remains limited to primary production centers. A study by Nelson et al. (2021) indicates that the availability of adaptive agricultural infrastructure can increase productivity by up to 25% in areas with high climate vulnerability.

Fifth, in the financial capital aspect, income diversification efforts have begun among agrarian communities in all study locations through the development of livestock farming, handicrafts, and service-based enterprises. Nevertheless, limited access to People's Business Credit/*Kredit Usaha Rakyat* (KUR) and the absence of climate risk-based agricultural insurance schemes continue to pose serious challenges in strengthening the economic resilience of farmers. In fact, a report by Oxfam (2020) highlights that the presence of community-based insurance schemes can reduce farmers' potential losses by up to 50% during extreme weather events.

Overall, the various adaptation strategies undertaken by agrarian communities in the three study areas indicate that resilience to climate change is not solely determined by environmental factors, but is also significantly influenced by human capacity, the strength of social networks, the availability of adaptive infrastructure, and access to financial resources. The integration of these five livelihood capitals within community-based adaptation strategies constitutes a key component in building sustainable agrarian resilience amidst growing climate uncertainty.

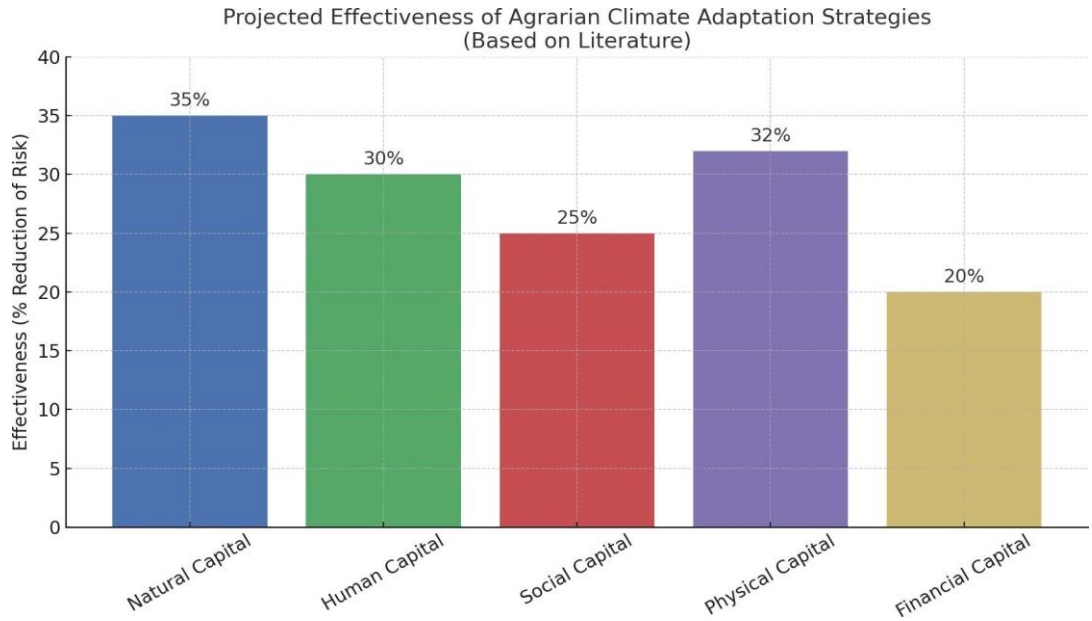

Fig. 2. Projected Effectiveness of Agrarian Climate Adaptation Strategies (FAO (2022), Oxfam (2020), Nelson et al. (2021), Pretty (2003))

3.3 Structural and institutional constraints

Despite various adaptation efforts implemented in agrarian communities, this study's analysis reveals that the enhancement of community resilience remains hampered by several structural, institutional, and socio-economic challenges. These persistent obstacles not only slow down the effective implementation of climate adaptation initiatives but also exacerbate the vulnerability of farming communities, particularly in remote and marginalized areas.

Tabel 5. Structural and institutional barriers to agrarian climate adaptation in indonesia

No.	Type of Barrier	Description	Key Reference
1.	Weak Inter-Agency Coordination	Fragmented implementation of adaptation programs; overlaps and lack of synergy.	Wreford et al. (2010)
2.	Limited Access to Climate Data	Inadequate dissemination of seasonal forecasts; poor data literacy among farmers.	FAO (2022)
3.	Financial and Technological Constraints	High costs and limited availability of adaptive agricultural technologies and credit schemes.	Nelson et al. (2021)
4.	Marginalization of Local Knowledge Systems	Exclusion of traditional ecological practices such as *subak*, *sasi*, and hifting cultivation from formal policies.	Yuliana (2020); Dove (1993)

First, the implementation of climate adaptation policies at the regional level often suffers from weak inter-agency coordination. Different sectoral offices, such as agricultural, environmental, and public works agencies, tend to run adaptation programs independently, without an integrated framework or clear division of responsibilities. This fragmentation results in overlapping projects, inefficiencies in resource allocation, and the absence of synchronized adaptation roadmaps. A study by Wreford et al. (2010) emphasizes that institutional synergy is essential for ensuring that adaptation measures are effectively mainstreamed across various development sectors.

Second, limited access to real-time, reliable, and localized climate data poses a significant constraint for farmers in accurately determining planting schedules and crop selection. Although national agencies such as BMKG have developed seasonal prediction tools, these resources often fail to reach farmers at the grassroots level due to weak dissemination systems, technical illiteracy, and infrastructural limitations in rural areas. According to FAO (2022), access to climate information can reduce agricultural risks by 30–40%, yet this potential remains untapped in many Indonesian agrarian communities.

Third, the adoption of adaptive agricultural technologies—such as drought-resistant crop varieties, water-saving irrigation systems, and solar-powered pumps—is severely constrained by high investment costs and limited financial support schemes. Access to agricultural credit, particularly the government's People's Business Credit (KUR), remains low in rural and remote areas due to complex administrative procedures, collateral requirements, and lack of financial literacy. As noted by Nelson et al. (2021), the availability of affordable financing mechanisms is a determining factor in enabling farmers to adopt climate-resilient innovations.

Fourth, national and regional policies have not fully recognized and incorporated indigenous knowledge systems and customary practices into formal climate adaptation frameworks. Traditional systems such as *subak* in Bali, *sasi* in Maluku, and *ladang berpindah* (shifting cultivation) in Kalimantan and Sumatra embody locally tested adaptive strategies that regulate land use, water management, and forest conservation. However, as highlighted by Yuliana (2020) and Dove (1993), these knowledge systems are increasingly marginalized by top-down, standardized development programs that overlook cultural specificity and ecological contexts.

3.4 Theoretical and policy implications

The findings of this study highlight the relevance of the Sustainable Livelihood Framework in understanding agrarian community resilience, showing that resilience is not solely shaped by physical environmental conditions but also by the strength of social capital, human capacities, and local institutional arrangements. Extending the work of Folke et al. (2010), this study emphasizes that the resilience of social-agrarian ecosystems must be supported by the community's capacity for social learning and adaptive innovation. From a policy perspective, several strategic priorities emerge, including the integration of cross-sector adaptation programs based on local climate data, the expansion of climate risk-based

agricultural insurance schemes with premium subsidies for smallholder farmers, the revitalization of farmer group institutions through adaptive leadership and risk management training, increased investment in research on climate-resilient local crop varieties and agroecology, and the mainstreaming of local wisdom practices into regional and national adaptation planning. Conceptually, community-based adaptation and livelihood diversification have proven to be among the most effective approaches to addressing climate uncertainty, especially in agrarian regions with limited physical and financial capital

4. Conclusion

This research confirms that climate change has had a real impact on the livelihood systems of agrarian communities in Indonesia, especially in vulnerable areas such as Wonosobo, Bima and Maros. Uncertainty in rainfall patterns, increasing temperatures, and frequency of extreme weather events have caused serious disruptions to food production cycles, agricultural productivity, and farmers' socio-economic welfare. Through an analysis based on the Sustainable Livelihood Framework (SLF), this research successfully identifies resilience adaptation patterns of agrarian communities that utilize various forms of livelihood capital, ranging from crop diversification, farmer capacity training, to strengthening community social networks.

An important contribution of this research is to provide a comprehensive picture of the dynamics of agrarian resilience in Indonesia by integrating the sustainable livelihood framework approach, national climate adaptation policies, and community-based local wisdom. The findings not only add to the scientific references in climate change studies in the tropical agricultural sector but also offer evidence-based policy recommendations to support adaptation planning at the local level. This research expands the understanding that increasing agrarian resilience does not solely depend on technical interventions, but also on institutional transformation, strengthening social capital, and mainstreaming local wisdom in adaptation strategies.

However, this study has several limitations. Firstly, the data used is entirely sourced from secondary documentation studies, so it has not been able to describe the social dynamics and direct experiences of farmers in depth. Secondly, this study only covers three purposively selected study areas, so the results cannot be generalized to all agrarian areas in Indonesia. Third, the analysis has not involved quantitative calculations of the level of resilience or economic losses due to climate change, which could strengthen the objective dimension of the research.

To broaden the understanding and increase the relevance of the results, some potential directions for future research include conducting a mixed-method field study by combining quantitative surveys and qualitative interviews to measurably measure the resilience index of farmers, as well as exploring the subjective experiences of communities in facing climate change threats. In addition, future research could also examine the effectiveness of climate risk-based agricultural insurance programs, evaluate early warning systems in agrarian villages, and study the potential integration of digital technology based on local climate data into community agricultural production systems. Cross-regional research with different agroecological characteristics is also important to produce more specific and contextualized adaptation recommendations. Thus, this research is expected to be an initial foundation for the development of policies and practices of climate change adaptation based on agrarian communities in Indonesia that are more inclusive, participatory and sustainable.

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Author Contribution

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