STRATEGY OF DROUGHT DISASTER MITIGATION IN NORTH CENTRAL TIMOR DISTRICT, EAST NUSA TENGGARA PROVINCE, INDONESIA

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Abstract

Drought is a natural disaster that threatens and disrupts people's lives, where the demand for water remains constant or even increases, while groundwater reserves decrease, leading to insufficient water availability for daily needs. To formulate an effective drought disaster mitigation strategy, an analysis of the drought disaster risk level must first be conducted. Mapping disaster risk areas plays a crucial role in supporting effective decision-making for disaster management. In line with the research objectives, the paradigm of disaster risk, disaster mitigation, and drought-related theories can be synthesized into several indicators for determining drought disaster risk levels. As the dry season progresses, North Central Timor Regency experiences severe drought, resulting in water availability falling far below the required levels for domestic use, agriculture, the economy, and the environment. Residents are forced to purchase water tanks to irrigate their drying rice fields and buy drum water daily to meet their household needs. This study employs both qualitative and quantitative research methods. The disaster risk level is formulated using Delphi analysis and the Analytical Hierarchy Process (AHP), while the identification of drought disaster mitigation strategies is conducted through descriptive analysis.

Keywords: Disaster Risk, Mitigation, Drought, Delphi Analysis

INTRODUCTION

According to Yunus & Damansyah (2021), a disaster is defined as an event that occurs either suddenly or gradually, posing threats to public health, safety, life, and livelihoods due to natural or non-natural factors (Book of Disaster Management Anthology, 2023). Horizontally, natural disasters can be classified into two categories: actual disasters and potential disasters. An actual disaster is an event that occurs suddenly, progresses rapidly, affects a limited area, and results in relatively few fatalities compared to the global scale. Examples include earthquakes, tsunamis, volcanic eruptions, flash floods, and other natural disasters. In contrast, potential natural disasters develop slowly over a long period, affecting vast areas and posing severe risks to all forms of life on earth. Examples include drought and land degradation (Hermon, D., 2015).

Natural disasters in Indonesia occur primarily due to its geographical location at the convergence of three tectonic plates: the Indo-Australian Plate (moving north), the Eurasian Plate (moving south), and the Pacific Plate (moving from east to west). The interaction of these plates exerts pressure on the Earth's lower layers, resulting in Indonesia's mountainous terrain and rough relief. Additionally, Indonesia lies within the Pacific Ring of Fire, which is characterized by a chain of active volcanoes extending from west to east (Hermon, D., 2015).

The study of disaster potential is inseparable from disaster mitigation management, which serves as a strategy for addressing spatial issues arising from direct disaster impacts (Rivi, 2019). Disaster mitigation refers to a series of efforts aimed at reducing disaster risks through physical development, awareness programs, and capacity-building initiatives to mitigate casualties and property damage when disasters occur (Disaster Management Book, Rivai & Nur Ayini, 2022).

One of the most prolonged and impactful disasters requiring mitigation efforts is drought. Drought is generally defined as a prolonged period of water shortage in a particular area, leading to soil moisture deficits (Disaster Management Book, Nakoe & Nur Ayini, 2022). Given the critical role of water resources for all living beings, efforts to combat drought and enhance quality of life should include constructing reservoirs, reforestation, and promoting water conservation measures.

In Indonesia, drought frequently occurs during the dry season, affecting multiple regions, including East Nusa Tenggara (NTT) Province. According to the Indonesian

Meteorology, Climatology, and Geophysics Agency (BMKG) report in December 2023, NTT is among six regions predicted to experience drought in 2024, alongside Lampung, parts of Java, Bali, West Nusa Tenggara (NTB), and southern Papua. The Disaster Risk Assessment (KRB) for East Nusa Tenggara Province (2021-2026) identifies North Central Timor Regency as one of the regions classified under a high drought hazard level.

During the 2021 dry season, drought impacted 187 villages across 24 sub-districts in North Central Timor Regency. According to Kompas.com (October 2024), 95 villages in 19 sub-districts of the regency were declared under emergency status due to drought conditions. BMKG's rainfall data for October 2024 indicates that several sub-districts, including Biboki Anleu, South Biboki, West Insana, and Insana, recorded extremely low rainfall levels (0-20 mm/month).

Unpredictable and insufficient rainfall restricts agricultural activities, limiting crop harvests to just once a year. To sustain their fields, some landowners purchase water tanks, with prices ranging from IDR 100,000 to IDR 150,000 per tank—a cost that can reach millions of rupiah for larger land areas. The drought crisis is further exacerbated by limited access to clean water sources. The region's limestone-dominated geography leads to groundwater contamination with saltwater, making it unsuitable for consumption. As a result, residents are forced to buy water, with one drum selling for IDR 15,000. On average, households require two drums of water per day for their daily needs.

RESEARCH METHOD

This study adopts a mixed-method approach, combining both quantitative and qualitative research methodologies. The quantitative component involves data collection from a specific population or a randomly selected sample, utilizing research instruments and statistical analysis to test predefined hypotheses, as outlined by Sugiyono (2004). In parallel, the qualitative approach serves as a process of exploration and understanding based on methodological traditions that investigate social phenomena and human issues. This method involves the construction of a complex narrative, the analysis of textual data, the presentation of detailed insights from the respondents' perspectives, and is conducted within naturalistic settings, following Creswell's (1998) framework.

In terms of data collection, the study integrates both secondary and primary data sources. Secondary data collection is employed to simplify and structure complex information into tables, diagrams, and analytical summaries. The secondary data includes the basic physical shapefile of North Central Timor Regency derived from the Regional Spatial Planning (RTRW) of the region, along with population statistics, forest area data, and drought incidence data sourced from the Central Statistics Agency of North Central Timor Regency. Primary data, on the other hand, is obtained through interviews and questionnaires aimed at acquiring specific information related to drought mitigation strategies applicable within the regency.

Data analysis in this study is conducted through a series of analytical techniques. To determine the factors influencing vulnerability in North Central Timor Regency, a combination of descriptive analysis, Delphi analysis, and Analytical Hierarchy Process (AHP) is utilized. The descriptive analysis involves comparing current conditions with predefined parameters, while the Delphi technique is employed to identify key vulnerability factors through expert consensus. AHP is then used to assign weightings and rank the significance of each factor influencing regional vulnerability.

To identify drought disaster risk zones in the study area, the analysis incorporates Geographic Information Systems (GIS) and ArcMap software. This includes the application of the Weighted Overlay technique to integrate multiple data layers, followed by overlay analysis using Map Algebra tools such as the Spatial Analysis Tools and Raster Calculator. The risk assessment is based on the formula: Disaster Risk = Hazard × Vulnerability. Input data for this phase comprises hazard zone maps and vulnerability zone maps, which are combined to produce a comprehensive drought disaster risk map for the region.

Finally, the determination of appropriate mitigation strategies is conducted through Descriptive Comparative Analysis. This method begins with a descriptive approach to address actual problems by systematically collecting, organizing, classifying, analyzing, and interpreting relevant data. It then proceeds with a comparative analysis of three main types of mitigation strategies—relocation, adaptation, and protection. A mitigation strategy matrix is subsequently developed to assess the effectiveness of each approach in managing drought risks within North Central Timor Regency.

RESULTS AND DISCUSSION

History of Drought in North Central Timor Regency

Drought in North Central Timor (TTU) Regency is a recurring natural disaster that has been increasing in intensity over the past few years. This prolonged drought has significantly impacted both society and the environment. According to one source, North Central Timor Regency is a semi-arid region that experiences drought almost year-round due to low rainfall and a dry season lasting 4–6 months. The persistent drought conditions in TTU Regency have made it difficult for residents to meet their daily needs.

Based on information from other sources, drought occurs from May to November, with its peak in October. A total of 95 villages across 19 sub-districts experience drought due to damaged irrigation systems, decreased agricultural productivity, and limited access to clean water. During the dry season, extreme heat is common, with temperatures reaching 36–38°C. The sub-districts most frequently affected by drought include East Miomaffo, North Bikomi, South Bikomi, Bikomi Nilulat, Naibenu, North Insana, Biboki Monleu, Biboki Anleu, North Biboki, Biboki Feotleu, South Biboki, Biboki Tanpah, Insana, West Insana, Central Insana, and Insana Fafines.

Determination of Factors Influencing Drought Vulnerability

Based on the Delphi analysis, several vulnerability factors were identified and categorized into social, economic, and environmental factors. In terms of social vulnerability, population density and the ratio of women to men reached a 100% consensus as key factors influencing drought vulnerability. However, the poor household indicator only reached a 35% consensus and was excluded from the study. Respondents argued that as long as existing water reserves were distributed equally, the economic level of households should not be considered a determinant of vulnerability.

For economic vulnerability, agricultural land area and productivity were identified as significant factors, achieving 100% consensus. Meanwhile, in environmental vulnerability, natural forest, protected forest, and shrubland were deemed important factors, also reaching 100% consensus. However, the mangrove forest indicator reached only 70% consensus and was excluded. Respondent 3 argued that mangrove forests primarily function to protect coastal areas from abrasion rather than directly influencing drought vulnerability.

After determining the relevant vulnerability factors, the next step was to overlay social, economic, and environmental vulnerability maps using the Weighted Overlay tool in ArcGIS 10.1, applying weights derived from the AHP analysis. The weights assigned to each drought vulnerability factor in North Central Timor Regency are presented in the table.

Table 1
Drought Vulnerability Results

Indicator	Weight
Social Vulnerability	320
Economic Vulnerability	122
Environmental Vulnerability	558

Source: 2025 Analysis Results

From the table and image above, it can be seen that the most influential drought vulnerability factor in North Central Timor Regency is environmental vulnerability, which has a weight of 558, followed by social vulnerability with a weight of 320 and economic vulnerability with a weight of 122. The overlay results in the form of a drought vulnerability map in North Central Timor Regency can be seen in the following table and map.

Table 2
Drought Vulnerability Results per District

Subdistrict	Score	Information
Biboki Anleu	3	Somewhat Vulnerable
Biboki Feotleu	2	Less Vulnerable
Biboki Moenleu	3	Somewhat Vulnerable
South Biboki	2	Less Vulnerable
Aunt Tan Pah	2	Less Vulnerable
North Biboki	2	Less Vulnerable
Bikomi Nilulat	2	Less Vulnerable
South Bikomi	3	Somewhat Vulnerable
Central Bikomi	3	Somewhat Vulnerable
North Bikomi	3	Somewhat Vulnerable
Insane	3	Somewhat Vulnerable
West Insana	5	Very Vulnerable
Insana Fafinesu	3	Somewhat Vulnerable
Middle Insana	3	Somewhat Vulnerable
North Insana	2	Less Vulnerable
City of Kefamenanu	3	Somewhat Vulnerable
West Miomaffo	2	Less Vulnerable
Central Miomaffo	3	Somewhat Vulnerable
East Miomaffo	4	Prone to
Music	1	Not Vulnerable
Mutis	3	Somewhat Vulnerable
Naibenu	3	Somewhat Vulnerable
Noemuti	3	Somewhat Vulnerable

Subdistrict	Score	Information
East Noemuti	3	Somewhat Vulnerable

Source : 2025 Analysis Results

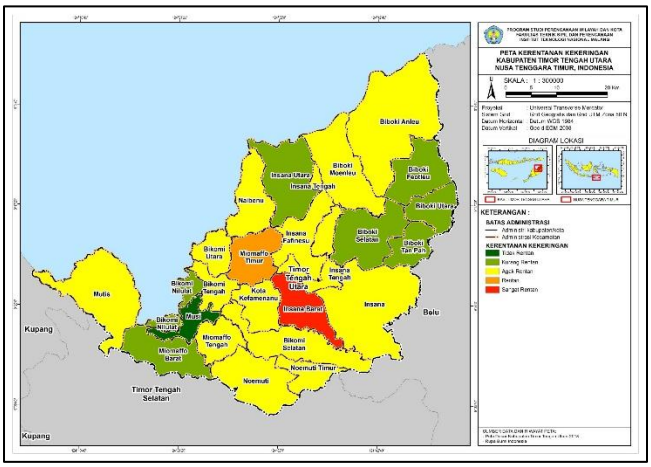


Figure 1
Drought Vulnerability of TTU Regency

Analysis of Drought Disaster Risk in North Central Timor Regency

The analysis of the formulation of drought disaster risk zoning in North Central Timor Regency was carried out by overlaying hazard maps and vulnerability maps using the raster calculator tool in ArcGIS with a risk formula, namely Hazard x Vulnerability.

Table 3
Drought Disaster Risk Results

Risk	Wide	Percentage
Low	1339.9	51.24
Currently	1182.1	45.21
Tall	92.8	3.55

Source: 2025 Analysis Results

The overlay results show the level of drought risk in North Central Timor Regency. Most of it is included in the low risk with a land area percentage of 51% with an area of 1339.9 km^2, followed by a medium risk zone with a percentage of 45% with an area of 1182.1 km^2, and a high-risk zone of 3% with an area of 92.8 km^2. The overlay results also show that there is 1 sub-district in North Central Timor Regency, part of which is included in the high-risk zone, namely West Insana District, with a high vulnerability area of 92.8 km^2.

Table 4
Results of Drought Disaster Risk per District

Subdistrict	Score	Vulnerability	Area (Km^2)
Biboki Anleu	1	Low	300.6
Biboki Feotleu	1	Low	105.1
Biboki Moenleu	1	Low	150.1
South Biboki	1	Low	136.8
Aunt Tan Pah	1	Low	60.5
North Biboki	1	Low	65.3
Bikomi Nilulat	1	Low	39.4
South Bikomi	2	Currently	139.1
Central Bikomi	2	Currently	47.3
North Bikomi	2	Currently	50.0
Insane	1	Low	7.0
Insane	2	Currently	245.6
West Insana	3	Tall	92.8
Insana Fafinesu	1	Low	55.9
Insana Fafinesu	2	Currently	39.3
Middle Insana	1	Low	40.3
Middle Insana	2	Currently	46.4
North Insana	1	Low	142.5
City of Kefamenanu	2	Currently	70.4
West Miomaffo	1	Low	108.0
Central Miomaffo	2	Currently	62.4
East Miomaffo	2	Currently	89.4
Music	1	Low	48.0
Mutis	2	Currently	188.5
Naibenu	1	Low	80.4
Naibenu	2	Currently	17.5
Noemuti	2	Currently	133.4
East Noemuti	2	Currently	52.7

Source: 2025 Analysis Results

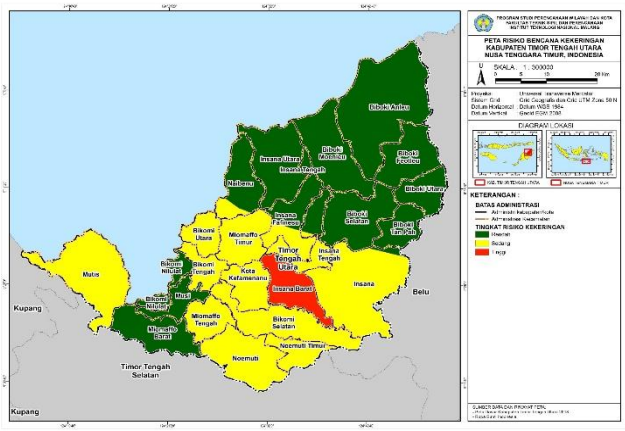


Figure 2
Drought Disaster Risk in North Central Timor Regency

Drought Disaster Mitigation Strategy in North Central Timor Regency

Table 4
Matrix of Respondents' Responses to the Drought Disaster Mitigation Strategy Variables in North Central Timor Regency

Variables	Code	Form of Mitigation Strategy	Respondents												Results
			1	2	3	4	5	6	7	8	9	10	11	12	
Relocation	S.1	The process of moving or relocating a community, society or individual from their place of origin to a new place due to certain reasons such as natural disasters.													
Adaptation	S.2	Human adaptation to the environment is adjusting to environmental changes. Definition													
Protection	S.3	Efforts or actions to protect communities, infrastructure and the environment from the impact of natural disasters or other disasters.													

Source: 2025 Analysis Results

Based on the matrix table of respondents' responses to the variables of drought disaster mitigation strategies in North Central Timor Regency obtained from the interview results, it can be concluded that all respondents agreed to carry out adaptation and protection mitigation. However, respondents 3,4,5,7,8,9, and 11 refused to carry out relocation mitigation strategies due to the following reasons:

1) No need for relocation due to short-term drought (R3, R9)
2) It is not certain that residents will get access to ready-to-live-in houses or ready-to-build plots (R7)

3) People will lose their homes; their villages are the place of their ancestors and forefathers (R4. R5, R8)
4) To move a resident's house/residence, a traditional ritual is required (R11)

Table 5
Disaster Adaptation Mitigation Matrix for North Central Timor Regency

Variables	Forms of Mitigation Activities	1	2	3	4	5	6	7	8	9	10	11	12	Results
Adaptation	1. Physical Adaptation													
	Provision of Reservoirs													
	Boreholes													
	2. Social Adaptation													
	Water Usage Priorities													
	Giving each other access to clean water													
	Drought disaster socialization													
	3. Economic Adaptation													
	Diversification of livelihoods													
	Use of technology to save water													
	Small business development													
	Use of local resources													
	4. Agricultural Adaptation													
	Soil fertility maintenance													
	Planting Pattern													
	Development of tolerant/resistant plant species (to drought, salt, insects/pests)													
	Diversification and intensification of food crops and plantations													

Source : 2025 Analysis Results

Based on the matrix table of respondents' responses regarding adaptation-based mitigation strategies in addressing drought disasters in North Central Timor Regency, the findings indicate several recommended activities that can be implemented. These activities are categorized into four main types of adaptation: physical, social, economic, and agricultural.

In terms of physical adaptation, the strategies identified include the provision of water tanks and the development of boreholes to ensure reliable water access during periods of drought. Social adaptation involves promoting water use prioritization among communities, encouraging mutual assistance in securing access to clean water, and increasing public awareness through drought disaster socialization efforts.

From an economic perspective, adaptation is directed toward the development of small-scale businesses and the optimization of local resource utilization to sustain livelihoods during and after drought events. Meanwhile, agricultural adaptation encompasses several key strategies, such as maintaining soil fertility, adjusting planting patterns, introducing crop varieties that are resistant to drought, and diversifying the processing of existing agricultural yields to enhance food security and income resilience.

These findings suggest a comprehensive and community-oriented approach to drought mitigation in North Central Timor Regency, emphasizing both infrastructural development and behavioral adaptation to reduce vulnerability and enhance resilience.

Respondents 3 and 9 disagreed with the adaptation strategy of providing mutual access to clean water, arguing that during a drought, it is more important to store water for oneself and one's family rather than sharing it with neighbors or others, as everyone faces difficulties in obtaining clean water. Similarly, respondents 1–5 and 7–10 opposed the adaptation strategy of livelihood diversification, stating that the community is already accustomed to drought conditions, and the economic impact is not severe enough to force a change in profession. Instead, farmers adapt by changing the types of crops they cultivate to ensure survival.

Furthermore, all respondents (1–12) disagreed with the adaptation strategy of implementing water-saving technology, explaining that while they would welcome government assistance in this regard, they had not observed any significant government intervention in water-saving efforts. Lastly, respondents 3 and 4 opposed the adaptation

strategy of utilizing local resources and diversifying harvests, as they preferred to use their produce for personal consumption rather than processing and selling it during drought conditions.

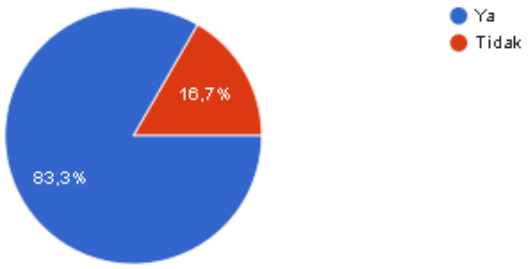
Discussion

The protection mitigation strategy of reservoir and embankment construction can be focused on areas that do not yet have reservoirs and embankments, as in the questionnaire results, 2 locations do not yet have reservoirs or embankments. Protection mitigation efforts are carried out by water harvesting/water conservation by making reservoirs or embankments to store water during the rainy season so that it can be used when the dry season arrives.

In addition to protection-based mitigation strategies, adaptation-oriented mitigation measures can also be implemented to address the challenges posed by drought disasters in North Central Timor Regency. These adaptation strategies are particularly important for enhancing community resilience and ensuring the sustainability of local livelihoods. One of the key components of such strategies is physical adaptation, which in this context is manifested through the provision of water infrastructure.

The physical adaptation efforts identified for North Central Timor Regency focus primarily on two main interventions: the provision of water tanks and the construction of drilled wells. The first initiative, namely the provision of water tanks, is aimed at establishing a structured and systematic program for the installation and maintenance of large-capacity clean water storage facilities. These tanks are intended to serve areas that currently lack access to adequate water storage infrastructure. Based on interview data gathered from local respondents, approximately 10.7% reported that there were no water tanks available in the vicinity of their homes, highlighting the urgent need for this intervention.

Such findings underscore the necessity of targeted and well-planned physical adaptation strategies to mitigate the impacts of drought and improve access to clean water in vulnerable communities throughout the region.



Another key physical adaptation strategy implemented in North Central Timor Regency is the development of boreholes. These drilled wells are constructed by penetrating the ground using specialized equipment to access groundwater located at specific depths beneath the surface. The availability of boreholes facilitates improved water access not only for households but also for industrial and commercial sectors. As reported by a representative from BAPPEDA (Respondent 1), the borehole development program has been widely implemented across various areas in the region. This initiative aims to improve community access to clean water, which remains a critical and urgent need. Respondent 1 emphasized that both boreholes and water reservoir tanks serve as long-term infrastructure solutions for addressing water scarcity in the regency.

In addition to physical adaptation, social adaptation plays a crucial role in building community resilience against drought. Social adaptation refers to actions carried out through interpersonal cooperation and mutual support. One such measure is the prioritization of water usage based on necessity. Interviews with respondents revealed that 91.7% of the population prioritized water for essential domestic needs—such as bathing, washing, and sanitation—while 8.3% allocated water primarily for livestock. Another form of social adaptation involves the voluntary sharing of clean water access among neighbors, promoting communal solidarity during crises. However, interview findings also highlight a significant gap in government-led public education on drought management. Respondents noted a lack of formal socialization efforts and expressed a strong desire for informational programs that provide guidance on how to respond effectively to drought conditions.

Economic adaptation is also essential to maintaining the continuity of livelihoods during periods of environmental stress. In North Central Timor Regency, two primary strategies have been identified: the development of small-scale businesses and the utilization

of local resources. These initiatives help ensure that economic activities can continue even amid challenging climatic conditions.

From the agricultural perspective, several adaptation strategies have been introduced to optimize land use and sustain crop yields during drought periods. Maintaining soil fertility remains a core strategy, which involves the application of fertilizers and pest control methods regardless of seasonal variations. In addition, the implementation of strategic cropping patterns is crucial. These include intercropping, multiple cropping, mixed cropping, relay cropping, and sequential planting. Such techniques aim to maximize land productivity, enhance resource efficiency, and reduce the risk of crop failure, thereby increasing farmers' income and ensuring food security.

Another significant form of agricultural adaptation is the transition to drought-resistant crop varieties. Interviews confirmed that this approach has already been adopted by many farmers in the region, with crops such as corn, coconut, and cassava being commonly cultivated during dry seasons. Furthermore, crop diversification in post-harvest processing has emerged as an innovative economic response. Communities have begun transforming corn into various marketable products—such as fried corn, corn flour, and corn chips—using attractive packaging to boost sales. Other products include fried peanuts, coconut oil, and cassava chips, demonstrating how agricultural adaptation not only addresses food availability but also opens up income-generating opportunities.

Collectively, these adaptation mitigation strategies—spanning physical, social, economic, and agricultural domains—constitute an integrated approach to enhancing drought resilience in North Central Timor Regency. They reflect a combination of infrastructural improvements, behavioral changes, and local innovations grounded in community participation and local knowledge.

CONCLUSION

Based on the findings of this study, it can be concluded that the North Central Timor (TTU) Regency is predominantly categorized under low to medium drought disaster risk levels. However, one district, namely Insana Barat, is classified as having a high level of disaster risk. The spatial distribution of drought risk in TTU Regency shows that

approximately 51.24% of the region falls into the low-risk category, 45.21% into the medium-risk category, and only 3.55% into the high-risk category, as detailed in Table 1.6.

To address these varying levels of drought risk, several strategies have been identified and proposed. The mitigation efforts in TTU Regency are carried out through two main approaches: adaptation-based mitigation and protection-based mitigation. In terms of physical adaptation, the region prioritizes the provision of water tanks and the development of boreholes (drilled wells) to ensure access to clean water, particularly in vulnerable communities. Social adaptation measures include prioritizing domestic water usage, fostering community-based water sharing systems, and increasing public awareness through socialization regarding drought preparedness and response.

Economic adaptation is addressed through the encouragement of small business development and the optimized use of local resources to ensure economic sustainability during periods of water scarcity. In the agricultural sector, adaptation strategies focus on maintaining soil fertility, optimizing planting patterns, shifting to drought-resistant crop varieties, and diversifying the processing of agricultural products to enhance value and income.

Additionally, protection-based mitigation focuses on water harvesting and conservation techniques by constructing reservoirs and embankments to store rainwater during the wet season for use in the dry season. These combined strategies are aimed at enhancing the resilience of communities across TTU Regency in the face of recurring drought disasters.

Suggestions

In light of the study's results, several recommendations can be proposed. First, it is essential to conduct further and more detailed research on drought disaster mitigation in the TTU Regency to enrich the existing understanding and improve planning accuracy. Second, a deeper investigation into comprehensive drought disaster risk management strategies is necessary to formulate long-term and sustainable solutions. Third, the findings of this study are expected to serve as a valuable reference for local government authorities in their development planning processes, especially in the context of climate-induced hazards.

Moreover, the results should inform policy decisions regarding priority setting in the allocation of resources and the implementation of drought mitigation measures, particularly

in terms of community services and information dissemination. Finally, there is a critical need to enhance public awareness, especially in medium- and high-risk areas, so that communities can become more proactive and responsive in managing the impacts of drought disasters.

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