# Adaptive capacity of farming household to drought as an impact of climate change in Central Lombok Regency

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**Abstract.** Climate change has intensified the frequency and severity of drought events, significantly disrupting agricultural system and food security. This study assesses the adaptive capacity of farming households to drought impacts in Central Lombok Regency, Indonesia, one of the regions most affected by water scarcity. A sequential explanatory mixed-method approach was employed, integrating quantitative assessment through the Adaptive Capacity Index (ACI) and qualitative insights from semi-structured interviews with 111 respondents across five drought-prone sub-districts. The ACI incorporated five dimensions: human, social, economic. Cultural, and physical infrastructure. Result indicate that Pujut Sub-district demonstrates the highest adaptive capacity (ACI = 0.62, high category), driven by strong human resource development, social cohesion, and access to climate-related training programs such as Climate Field Schools. Meanwhile, Praya Barat shows the lowest ACI (0.27, low category), reflecting weak institutional networks and limited exposure to adaptation initiatives. Overall, social and cultural dimensions exhibited the strongest contributions to resilience, underscoring the significance of social capital and traditional values such as 'besiru' (cooperation) in sustaining adaptation practices.

## 1 Introduction

Drought has emerged as one of the most strategic and complex environmental issues of the last decade, exerting widespread socio-economic and ecological consequences across the globe [1]. It is considered a multi-dimensional hazard with cumulative and cascading effects on ecosystems, agriculture, and livelihoods. According to [2], drought can be classified into four categories-meteorological, hydrological, agricultural, and socio-economic-among which agricultural drought has the most direct and tangible impacts. It disrupts crop growth

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cycles, reduces soil moisture, and degrades ecosystem functions, resulting in significant yield losses and economic downturns. The immediate consequence of agricultural drought is reduced water availability, which not only hampers plant development but also undermines rural economies that rely heavily on agricultural productivity [3].

The intensification of drought events is closely linked to the accelerating pace of global climate change. In Indonesia, the El Nino-Southern Oscillation (ENSO) phenomenon-characterized by anomalous sea surface temperature fluctuations in the Pacific Ocean-has significantly altered rainfall patterns, disrupted the agricultural calendar and increased climate variability across the archipelago [4]. ENSO-driven rainfall anomalies have repeatedly triggered prolonged droughts that severely affect agricultural production, particularly in the eastern regions of Indonesia such as Nusa Tenggara Barat (NTB).

NTB Province represents one of Indonesia's most drought-prone regions due to its semi-arid climate and economist dependence on agriculture. The sector contributes approximately 22.23% to the province's Gross Regional Domestic Product (GRDP) and employs about one-third of its total labour force (approximately 85% of the total land area) [5], most agricultural activities rely on rainfed systems that are highly vulnerable to seasonal precipitation shifts. Among all districts, Central Lombok stands out as the province's major rice-producing area, accounting for over 25% of total rice harvests. However, rapid land-use transformation following the establishment of the Mandalika Special Economic Zone has Ied to significant reductions in agricultural land, replacing it with built-up areas and tourism infrastructure. This land conversion not only reduces agricultural productivity but also exacerbates drought intensity through diminished vegetation cover and weakened carbon sequestration capacity.

Spatial assessments indicate that drought vulnerability in Central Lombok ranges from moderate to severe, particularly in irrigated rice field system that depend on stable hydrological conditions. Paddy cultivation, which requires a continuous water supply, is highly sensitive to climatic extremes-both excessive rainfall and prolonged dry spells. Climate anomalies disrupt planting schedules, reduce water availability, and foster pest outbreaks, collectively threatening national food security. Empirical evidence further demonstrates that climate change has already diminished rice yields, constrained cropping cycles, and weakened agricultural resilience throughout Indonesia.

Given the scale of these risks, understanding farmer's adaptive capacity to drought is crucial for developing effective and context-specific adaptation strategies. Adaptive capacity reflects the ability of individuals, communities, and institutions to anticipate, prepare for, respond to, and recover from climate disturbance [6]. It encompasses multidimensional determinants-social, economic, cultural, institutional, and infrastructural-that shape the resilience of local livelihoods. Strengthening farmer's adaptive capacity is considered a strategic short-term approach to reducing vulnerability as internal determinants such as knowledge, skills, and networks are more manageable than external exposure and sensitivity factors.

Central Lombok provides a unique context for examining these dynamics, where traditional irrigation systems-managed through local institutions known as *pekasih* – continue to embody local wisdom and collective water governance. These indigenous practices represent enduring adaptive mechanisms that have sustained communities under fluctuating climatic conditions. However, the extent to which such socio-cultural systems enhance or constrain farmer's adaptive capacity remains underexplored. Therefore, this study aims to assess the **adaptive capacity of farming housheolds in drought-prone areas of Central Lombok Regency** by integrating both quantitative and qualitative dimensions. Specifically, it seeks to identify key determinants that contribute to local resilience, evaluate inter-district variations, and provide policy-relevant insight for strengthening climate adaptation planning in semi-arid agricultural regions of Indonesia.

## 2 Methods

The research employed a sequential explanatory mixed-method design, integrating quantitative ACI computation and qualitative narrative exploration. This research conducted in Central Lombok Regency, which consist of twelve sub-districts. Based on the drought-severity mapping from previous studies, five sub-districts within the regency have been identified as experiencing high level of drought risk (Figure 1). Data were collected from 111 farming households in five drought-prone sub-districts: Pujut, Praya Barat, Praya Barat Daya, Praya Tengah, and Janapria. Primary data were obtained through structured questionnaires and in-depth interviews, complemented by secondary data from government agencies and previous studies.

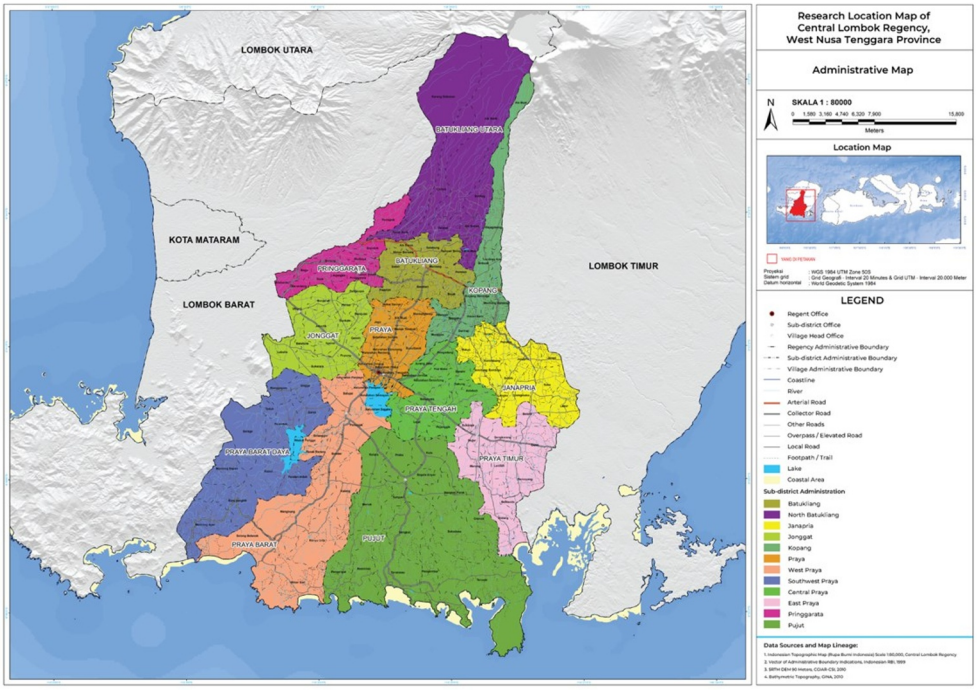


**Figure 1**. Maps of Administrative Boundaries in Central Lombok Regency

The ACI framework included five key dimensions: (1) Human resources (education, agricultural skills, technology adoption), (2) Social networks (participation, trust, collective action), (3) Economic capacity (income diversification, savings, financial access), (4) Cultural factors (local wisdom, compliance with customary rules), and (5) Physical infrastructure (irrigation, machinery, communication tools) [7]. Each variable was normalized and scored on a scale from 0 to 1, then aggregated to from composite indices per dimension and per sub-district. Strengthening adaptive capacity therefore requires not only

## 3 Result and Discussion

Central Lombok is the second most populous district in West Nusa Tenggara (NTB), accounting for 19.71% of the provincial population. In 2025 it also recorded the largest harvested rice area in NTB-70,777.87 ha (25.12% of provincial paddy area)-and agricultural remains the largest contributor to the district's GRGP at IDR 3,288 billion. This heavy structural reliance on agriculture heightens the district's sensitivity to climate anomalies. In

recent years, climate change has intensified seasonal water stress, triggering recurrent production risks and localized crises in farming systems.

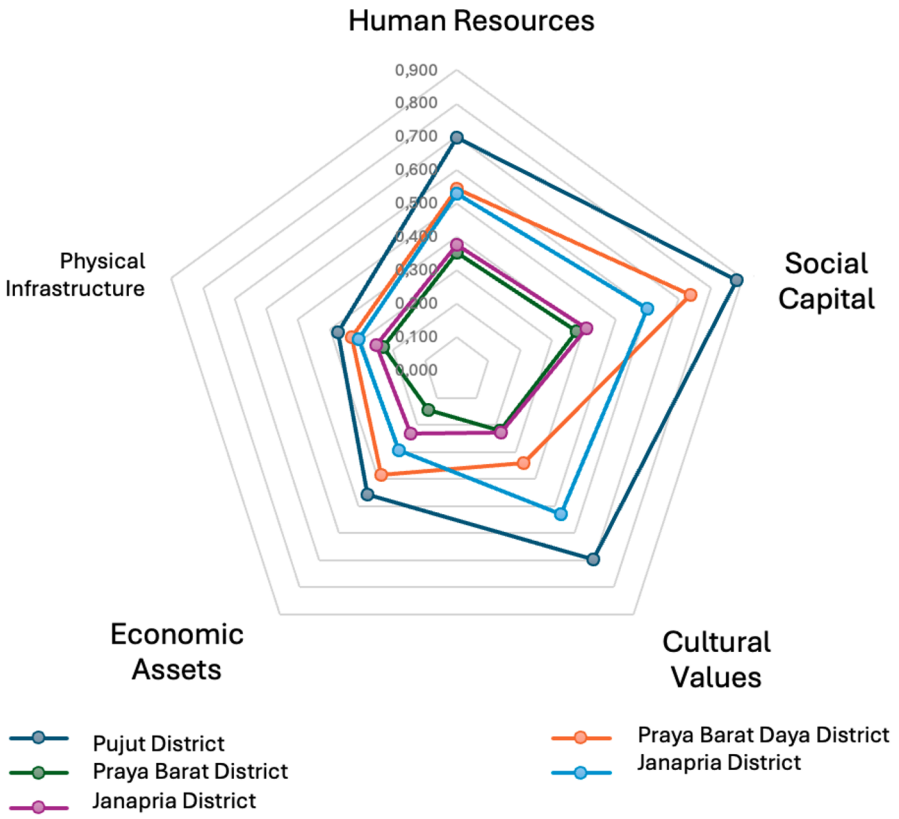


**Figure 2**. Average ACI Diagram

### 3.1 Spatial variation in Adaptive Capacity Index (ACI)

Adaptive capacity was assessed across drought-prone sub-districts using a composite ACI (Figure 2). Marked spatial heterogeneity emerged. Pujut achieved the highest ACI (0.62; high), while Praya Barat Daya ranked second (0.47; moderate). At the other end of the spectrum, Praya Barat displayed the lowest ACI (0.27; low). These contrasts underscore how location-specific institutional support, access to innovation, and socio-economic opportunities shape resilience trajectories even within a single district.

Pujut's leading position reflects overlapping advantages: its integration within the Mandalika Special Economic Zone has brought repeated exposure to national and local programs, including Climate Field Schools (SLI) and SIMURP since 2021, which improved climate literacy and irrigation management. Technological uptake associated with Climate-Smart Agriculture (CSA)-such as drip irrigation supported by IoT-has increased, alongside farmer empowerment along the value chain and diversification from staple crops to higher-value horticulture. Market linkages to hotels and retail in greater Central Lombok have further bolstered adaptive options. Socially, the persistence of besiru and other cooperative norms continues to provide the social capital required for collective action and risk sharing.

Praya Barat Daya's moderate score is driven by a relatively strong social and human-capital base-partly due to SIMURP participation and close relations with extension services. In some of the driest villages, NGO support (e.g., Berugak Desa) has facilitated conservation

practices and crop rotations that help maintain soil fertility and stabilize yields. By contrast, Praya Barat exhibits a combination of low social mobilization, limited program reach, and a predominance of rainfed systems, all of which dampen the absorption of extension advice and constrain timely adaptation.

Recent scholarship on the Adaptive Capacity Index (ACI) provides important conceptual and empirical insight that further strengthen the interpretation of the results obtained in Central Lombok. The study [8], highlight that adaptive capacity in agricultural communities in increasingly shaped not only by traditional determinants-such as education, assets, and infrastructure-but also by emerging factors including institutional connectivity, innovation exposure, and information access. These findings align closely with the conditions observed in Pujut Sub-district, where repeated engagement with Climate Field Schools and development initiatives under the Mandalika Special Economic Zone has expanded farmers access to knowledge networks and technological experimentation, resulting in the highest ACI score in the region. This reflects the global trend that regions with dense institutional landscapes tend to outperform more structurally isolated areas in achieving climate readiness.

Similarly, the system review by [9] emphasizes that adaptive capacity should be understood as a dynamic property of socio-ecological systems, shaped by interactions between local governance, social cohesion, and cultural norms. The strong social and cultural dimensions in Central Lombok-manifesting in practices such as gotong royong, besiru, and the persistent use of awig-awig resonate with international evidence showing that community-based governance and collective norms significantly elevate resilience in contexts where material and infrastructural capacities remain constrained. This theoretical framing helps explaining why the social dimension recorded the highest score (0.601) across all sub-districts: communal cooperation not only facilitates collective water management but also serves as a form of informal insurance during prolonged drought, consistent with patterns identified in agrarian communities in Nepal, Ethiopia, and the Indian Gangetic Plains.

The ACI literature also underscores the centrality of economic diversification in strengthening rural resilience. Based on [10], studying fishermen in the Spermonde Islands of Indonesia, demonstrates that livelihood diversification-not merely physical infrastructure-plays the most decisive role in reducing climate vulnerability. This observation directly parallels the situation in Central Lombok, where Pujut's higher level of income diversification (through horticulture, tourism-linked supply chains, and non-farm employment) contributes substantially to its higher adaptive capacity. In contrast, sub-districts such as Janapria and Praya Barat exhibit narrow livelihood structures dominated by rainfed rice cultivation, which mirrors the low-ACI zones identified by [8] in the drought-prone alluvial plans of North India.

Another important insight from recent ACI frameworks concerns the role of information access, early warning systems, and digital tools. [9] argue that modern adaptive capacity increasingly depends on farmers' engagement with climate advisories, ICT-based tools, and decentralized information networks. This perspective helps contextualize the moderate-to-high human capital scores in Central Lombok, where participation in Climate Field Schools and the utilization of BMKG planting calendar guidance has enhanced climate literacy. However, the uneven diffusion of these programs-especially in upland and rainfed areas-echoes the disparities noted in adaptive capacity assessments across Asia and Africa, where knowledge systems often fail to penetrate peripheral regions.

Overall, integrating the findings recent ACI studies provides a stronger theoretical basis for understanding the observed spatial variation in Central Lombok. The results confirm that adaptive capacity is not solely a function of material resources but arises from the synergy between institutional access, social cohesion, livelihood flexibility, and information connectivity. These insights reinforce the conclusion that strengthening resilience in drought-prone regions like Central Lombok requires a holistic approach-one that simultaneously

advances human capital development, revitalizes socio-cultural institutions, enhances financial and livelihood diversification, and addresses persistent infrastructure deficits.

### 3.2 Human Capital Dimension

The Human Resources dimension emerged as a key driver of adaptive capacity. Indicators included formal education, productive age structure, working household members, knowledge of drought risk and cropping calendars, conservation skills, technology adoption, work diversification, and participation in capacity-building. Despite substantial programmatic inputs (e.g., SLI by BMKG-IPB; NGO initiative in Pujut and Praya Barat Daya; SIMURP on irrigated schemes; Table 1). Coverage remains uneven-particularly in highland and sloping rainfed areas most prone to drought. These areas often experience shortened rainy seasons that culminate in crop failure.

On average, the Human Resources dimension attained 0.501 (high). This indicates that farmers generally possess sound conceptual knowledge-rotation, balanced fertilization, erosion risk on steeper slopes, and soil-water conservation. However, translation into practice is inconsistent. Economic pressures and habit persistence often override extension recommendations, resulting in short-term choices that undermine long-term sustainability.

This "knowledge-action gap" has been reported globally, where farmers understand climate risk but are constrained by financial limitations, risk perceptions, or labour trade-offs. Key constraints identified include: 1) Liquidity shortages preventing adoption of improved varieties or water-saving technology; 2) Risk aversion due to uncertainty in rainfall and market prices; and 3) Persistence of habitual practices inherited across generations. Thus, strengthening human capital requires not only training but institutional mechanisms that reduce risk and lower transaction costs, aligning with findings by [11], that climate literacy alone is insufficient without enabling economic incentives.

### 3.3 Social and Cultural Dimension

The Social dimension recorded the highest mean score across sub-districts-0.601 (high) (Figure 3)-signalling the centrality of social capital in climate resilience. Strong ties among farmers, local organizations (farmer groups and Gapoktan), and water-user groups support information exchange, collective water allocation (e.g., Beresih and Nyalin Aik systems), and mutual aid. In drought-intensive sub-district (Pujut, Praya Barat Daya, Praya Barat, Janapria, Praya Tengah), gotong royong, deliberation practices, and active farmer organizations remain salient features of communal life. These institutions not only channel external assistance and technology but also organize collective responses that reduce household-level vulnerability.

The prominence of the social dimension suggests that Lombok's farmer resilience is more dependent on networks and trust than on financial or physical endowments alone. Policy designs that leverage existing norms and local rules (awig-awig) are therefore likely to be more effective and durable than purely top-down technical prescriptions.

Globally, similar patterns are observed in Nepal, Ethiopia, Morocco, and Vietnam, where social capital significantly improves climate adaptation, especially under limited economic resources [12]. This result strongly aligns with these findings, implying that in conditions of infrastructural and financial scarcity, socio-cultural systems often substitute for formal adaptation tools. Importantly, local norms such as awig-awig function as environmental governance mechanisms regulating planting norms, irrigation fairness, and land use decisions, consistent with Ostrom-based analyses of community resource management. This highlights the critical need to integrate indigenous institutions into climate policy design, ensuring legitimacy and long-term adoption.

### 3.4 Economic Dimension

The Economic dimension scored 0.302 (low), the second lowest after the physical dimension. This indicates constrained financial buffers and limited capacity to absorb climate shocks. Pujut fares relatively better due to diversification opportunities linked to Mandalika-both in crop choices (e.g., shifts toward high-value horticulture) and non-farm activities. By contrast, Janapria (social ACI = 0.228) and Praya Barat (social ACI = 0.222) show weak economic resilience: heavy reliance on rainfed paddies, limited access to formal finance, minimal income diversification, and low value addition (most outputs sold as primary commodities). Thin market access-often mediated by tengkulak-further compresses farmgate prices, dampening incentives for adaptive investment. This constraint aligns with numerous studies showing that economic capacity-particularly savings, credit access, and livelihood diversification-is the single strongest predictor of whether smallholders can invest in adaptation technology.

The structural problem is that rainfed farmers in Central Lombok operate on narrow economic margins, reducing their ability to adopt drought-tolerant seeds, invest in pumps, or transition to horticulture. Praya Barat and Janapria reflect this clearly. Recent analyses also emphasize that climate adaptation is capital-intensive; thus, without economic buffers, farmers remain locked into low-productivity traps. This further explains the uneven adaptive capacity across sub-districts.

### 3.5 Physical-Infrastructure Dimension

The physical dimension is the most constrained. Farmers face: (i) limited irrigation coverage, with many plots dependent on rainfall and uneven water distribution during prolonged dry spells; (ii) low penetration of water-saving technologies (pump, drip systems) due to cost and access barriers; (iii) degraded conveyance (sedimentation, leakage) and inadequate storage (embung, recharge wells); and (iv) restricted access to machinery (tractors, pumps, post-harvest equipment). As a result, even where social capital is strong and human capital is growing, infrastructure gaps bottleneck the realization of adaptive strategies on the ground.

These align with Indonesia-wide patterns where irrigation inequality and degraded conveyance systems increase climate vulnerability. The result validates the argument that infrastructure is the binding constraint limiting the translation of social capital and human capital into effective climate action. Even where knowledge and cooperation exist, farmers cannot actualize adaptation without water availability. International studies (e.g., in Pakistan, Kenya, and Laos) similarly show that irrigation access is the single most transformative infrastructure for enabling drought resilience [13]. The centrality of irrigation as a binding constraint in climate adaptation is strongly supported [14]. Their study in the dryland areas of Mesuji, Lampung, Indonesia, demonstrated that improved irrigation supply-combined with appropriate nitrogen application significantly enhanced shallot growth and yield, even in highly water deficient environment. This empirical evidence affirms that water availability is the decisive factor enabling farmers to operationalize adaptive practices.

Strengthening adaptive capacity therefore requires not only physics-infrastructure but also access to soil-improving technologies that lower risks and increase system productivity. Biofertilizer-based strategies, as evidenced by [15], provide a practical pathway that aligns with climate-resilient land management and can support farmers in overcoming low-productivity traps associated with climatic stress.

The overall Adaptive Capacity Index (ACI) for Central Lombok Regency average 0.42, categorizing the region as moderately adaptive. However, significant inter-district variations were observed. Pujut Sub-district achieved the highest ACI (0.62), reflecting effective integration of human and institutional capacities through training programs and proximity to

development hubs. Praya Barat Daya followed with 0.47, supported by moderate human resource strength and active farmer group participation. In contrast, Praya Barat recorded the lowest ACI (0.27), primarily due to limited irrigation networks, weak farmer organizations, and low participation in adaptive agricultural training.

Among the five dimensions, the social dimension contributed most significantly (mean index = 0.60), driven by strong communal networks, cooperation systems ('gotong royong'), and collective water management traditions such as 'nyalin aik'. These traditional practices reflect deeply rooted social capital that sustains adaptive behaviour during drought periods. The human resource dimension followed (mean index = 0.50), reflecting the benefits of Climate Field Schools and the Strategic Irrigation Modernization and Urgent Rehabilitation Project (SIMURP), which enhanced climate knowledge and irrigation management.

Conversely, the economic and physical dimensions scored lower (0.30 and 0.28), respectively), indicating persistent structural challenges. Limited access to financial capital, dependence on rainfed systems, and inadequate irrigation infrastructure constrain adaptation. Despite these constraints, cultural resilience remains an enabling factor, where adherence to local norms ('awig-awig') and indigenous forecasting methods strengthen farmers' collective decision-making and ecological awareness. Synthesizing the ACI findings with stakeholder interviews (farmer groups, Gapoktan, P3A, extension agents, district agencies) yields four strategic pillars:

1. Rebuild climate literacy and sustained human capital
   Prioritize villages by spatial drought risk and vulnerability, co-design programs with communities from planning to participatory M&E and invest in comprehensive extension capacity (cognitive-affective-psychomotor, managerial, communication, innovation, and digital literacy). Scale the use of BMKG planting calendars and promote practical skills (rotation, drought-tolerant varieties). Restoring trust in programs is essential: collective learning platforms that let farmers map local climate signals and soil-water behaviour can convert abstract risk into actionable practice.
2. Leverage social and cultural capital through local institutions
   Revitalize farmer groups/Gapoktan beyond administrative roles to manage grain reserves and micro-finance for lean seasons. Reactivate gotong royong and inter-village forums to address climate issues jointly. Institutionalize awig-awig that integrate formal and customary rules for equitable irrigation allocation and restrict planting on slopes >40%. Utilize local wisdom (e.g., traditional water allocation, besiru) to legitimize compliance and accelerate uptake.
3. Unlock rural economic resilience
   Promote on-farm diversification (alternative drought-tolerant staples, horticulture), crop-livestock-agroforestry integration, and linked non-farm enterprises (local crafts, agro-tourism, processing). Expand group-based microfinance and harvest-based savings to build emergency funds. Strengthen value chains via partnerships with hotels/retailers (leveraging Mandalika) and reduce dependence on middlemen through digital village markets. Improve household financial literacy with basic farm bookkeeping to enable data-driven decisions.
4. Close the infrastructure gap
   Modernize water resources management (precision conveyance, small storage, recharge), expand water-saving irrigation, and maintain shared ALSINTAN collectively for longevity. Promote ecosystem-based soil and water conservation to protect fertility under drought. Adopt green infrastructure principles in irrigation investments. Establish digital agricultural information hubs at sub-district extension centres to integrate advisories, markets, and early warnings.

## 4 Conclusion

This study concludes that adaptive capacity among farming households in Central Lombok varies significantly across sub-district, influenced by the interplay of social, human, and economic factors. Social capacity-manifested through trust, cooperation, and local institutions-emerges as the strongest determinant of resilience. Enhancing adaptive capacity therefore requires integrated interventions: (1) strengthening human capital through continuous training and literacy programs, (2) revitalizing local institutions to reinforce social cohesion, (3) promoting livelihood diversification to reduce economic vulnerability, and (4) modernizing agricultural infrastructure within the framework of community-based adaptation. Future policies should prioritize participatory planning that combines scientific knowledge with indigenous practices to achieve sustainable climate resilience in rural agricultural landscapes.

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