



Rural resilience in the era of climate change: Community-based natural resource governance in coastal communities

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ABSTRACT

Background: Climate change is increasingly threatening the sustainability of rural communities whose livelihoods depend on natural resources. Although previous studies have emphasized the importance of community participation, local ecological knowledge, and collective governance in climate adaptation, limited empirical evidence explains how multiple community-based natural resource management (CBNRM) practices interact to strengthen village resilience within a social–ecological system. This study examines the role of CBNRM in enhancing climate resilience in villages of Rajabasa District, South Lampung Regency, Indonesia.

Methods: A qualitative case study involving 24 purposively selected informants from two villages was conducted, complemented by observations and document analysis. Data were analyzed through thematic analysis focusing on four dimensions: community-based water management, adaptive agricultural practices, land conservation, and human–environment relationships. Data saturation was reached across informant groups.

Findings: Community-based water governance, adaptive farming based on local ecological knowledge, collective land conservation, and strong social institutions are interconnected adaptive mechanisms that enhance village resilience. Water distribution is coordinated through farmer groups, agricultural adaptation is guided by local ecological knowledge and crop diversification, and soil productivity and water recharge areas are protected by conservation practices norms, cooperation, and local institutions strengthen adaptive capacity under increasing climate uncertainty. **Conclusion:** By integrating ecological knowledge, collective action, and sustainable environmental governance into mutually reinforcing adaptation strategies, community-based natural resource management enhances village resilience. **Novelty/Originality of this article:** This study extends the CBNRM, Social-Ecological Systems, and Adaptive Governance literature by demonstrating that village resilience emerges through the interaction of local institutions, ecological knowledge, and collective governance.

KEYWORDS: climate change; community-based governance; natural resource management; resilience; rural development.

1. Introduction

Climate change has emerged as one of the most pressing challenges to sustainable development, particularly for rural communities whose livelihoods are closely tied to natural resources (Piya et al., 2019; Swart et al., 2003). Increasing climate variability, including rising temperatures and more frequent extreme weather events, has significantly affected agricultural productivity, water availability, and the stability of local ecosystems

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that support rural livelihoods (Hoque et al., 2019; Kangana et al., 2024;). In this context, strengthening rural communities' adaptive capacity has become a critical component of climate resilience. Coastal regions are highly vulnerable to environmental change and climate-related disasters because ecological and socioeconomic conditions jointly influence the capacity of communities to adapt to environmental change (Adger, 2003; Adger et al., 2021).

South Lampung Regency is particularly exposed in Indonesia because of its location along the Sunda Strait and within the influence of Mount Anak Krakatau. The December 22, 2018, tsunami in the Sunda Strait underscored this vulnerability, causing severe casualties and infrastructure damage, including in Rajabasa (BNPB Indonesia, 2025). The Rajabasa District is characterized by rural communities whose livelihoods depend heavily on agriculture, fisheries, and other natural resource-based activities. In addition to disaster risks, local communities face environmental challenges such as land degradation, shifting seasonal patterns, and limited access to sustainable water resources (Mphande, 2016; Robinson, 2016). These conditions increase rural households' vulnerability and underscore the importance of strengthening local capacity in environmental management (Chen et al., 2024; Waugh, 2013). Previous studies indicate that communities in the Rajabasa coastal area exhibit relatively high levels of social vulnerability to disasters, emphasizing the need for strategies that integrate environmental management with community resilience (Nabillah et al., 2020).

Community-based natural resource management (CBNRM) has increasingly been recognized as an important framework for environmental governance in response to these challenges. This approach places local communities at the center of decision-making processes in natural resource management and emphasizes the importance of participation, local institutions, and ecological knowledge in maintaining ecosystem sustainability (Foyet, 2024; Thu & Middleton, 2024). Earlier studies on common-pool resource management demonstrate that communities can develop effective institutional arrangements for managing shared resources. These arrangements are particularly successful when supported by strong social norms and collective action (Julio et al., 2024; Roux et al., 2023). Furthermore, the adaptive capacity of communities facing environmental change is closely linked to the strength of local institutions, social networks, and collective resource management practices (Engle, 2011; Siders, 2019).

Despite the growing body of literature on climate change adaptation and coastal vulnerability, most studies focused on disaster mitigation strategies, vulnerability assessments, or the socioeconomic impacts of climate change (Anfuso et al., 2021; Lee et al., 2022). Previous studies have advanced understanding of climate risks but have provided limited explanations of how locally embedded resource governance strengthens long-term adaptive capacity. Existing CBNRM research mainly focuses on individual resource sectors or institutions, with limited evidence from Indonesia's disaster-prone coastal communities (Fatemi et al., 2017; Fekete, 2019). Consequently, empirical research is needed to examine how integrated community-based natural resource management practices—including water governance, adaptive agriculture, land conservation, and collective institutions—operate as interconnected adaptive strategies for strengthening village-level climate resilience.

Building upon these governance principles, the Social-Ecological Systems (SES) perspective provides a useful theoretical lens for understanding how community-based natural resource management contributes to resilience). However, the effectiveness of CBNRM has also been questioned because community institutions are not inherently inclusive or equitable. Previous studies have shown elite capture, unequal participation, power asymmetries, and limited institutional capacity may constrict local governance, which can reduce the effectiveness and legitimacy of community-based resource management (Agrawal & Gibson, 1999; Dressler et al., 2010). These critiques suggest that successful CBNRM depends not only on community participation but also on governance arrangements capable of ensuring accountability, inclusiveness, and adaptive learning. The framework synthesizes the key concepts derived from CBNRM, Social-Ecological Systems

(SES), and Adaptive Governance and serves as the analytical foundation for this study based on the theoretical perspectives discussed above. The conceptual framework is illustrated in Figure 1.

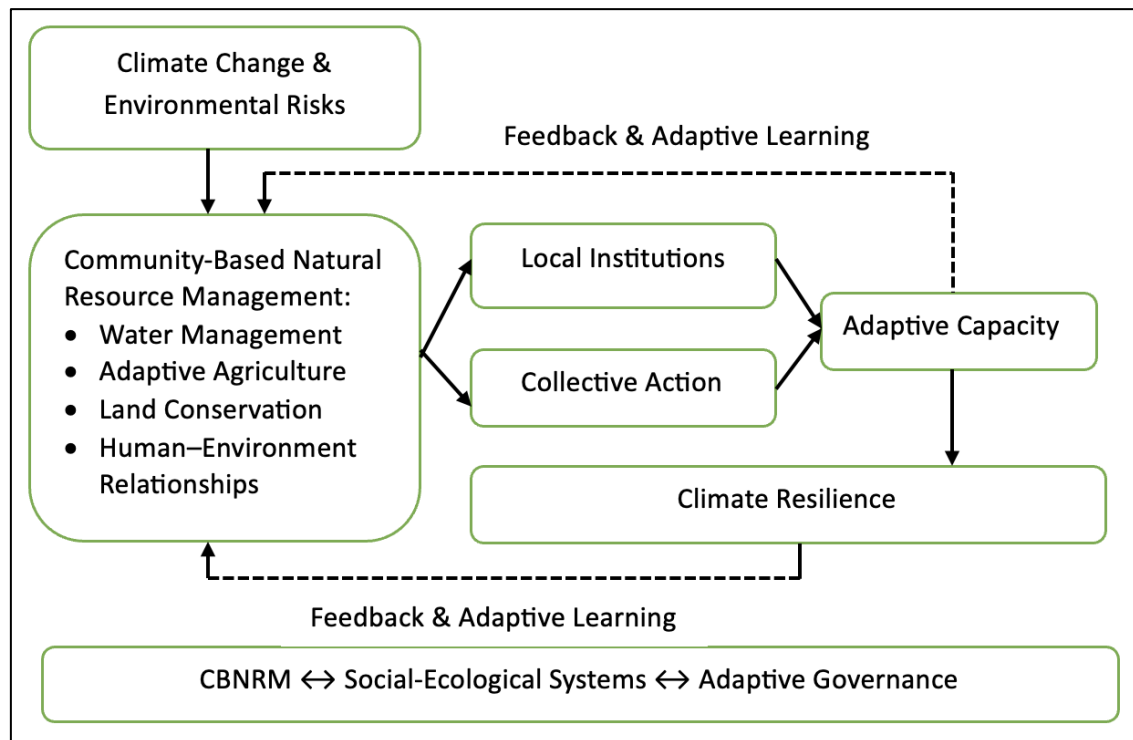


Fig. 1. Community-based natural resource management conceptual framework for strengthening village climate resilience

Against this background, this study aims to analyze community-based natural resource management practices in several villages in Rajabasa District, South Lampung Regency. It also examines how these practices contribute to strengthening village resilience to climate change. The analysis focuses on four key aspects: community-based water management, adaptive agricultural practices, land conservation strategies, and human–environment relationships in local natural resource governance. Specifically, this research addresses two central questions: (1) how rural communities in Rajabasa District implement community-based natural resource management practices and (2) how these practices contribute to village resilience in the context of climate change. This study contributes to the literature on community-based environmental governance and social–ecological resilience by demonstrating how village resilience is strengthened by integrated water management, adaptive agriculture, land conservation, and local institutions. Theoretically, this study extends the CBNRM literature by demonstrating how interactions among local institutions, ecological knowledge, collective action, and adaptive governance strengthen resilience in disaster-prone coastal villages.

2. Methods

This study employs a qualitative research approach using a case study design to examine community-based natural resource management practices and their contribution to strengthening village resilience to climate change. A qualitative case study is particularly appropriate for this research because it allows for an in-depth exploration of social processes, local knowledge, and collective practices that shape environmental governance at the community level (Baskarada, 2015; Cleland et al., 2021). The case study design enables the researcher to capture the complexity of interactions between social institutions,

local ecological knowledge, and natural resource management practices within specific socio-ecological contexts.

This study was conducted in Rajabasa District, South Lampung Regency, Indonesia, a coastal rural area that is highly dependent on agriculture, fisheries, and plantation activities and vulnerable to climate-related hazards. The villages of Sukaraja and Way Panji were selected based on their dependence on natural resources, community-based environmental management practices, and climate vulnerability. The unit of analysis was village-level community-based natural resource management. A total of 24 purposively selected informants, including village officials, community leaders, farmer group members, local residents, and entrepreneurs, participated based on their knowledge and involvement in natural resource management. Data were collected through three complementary techniques: (1) in-depth interviews, (2) field observations, and (3) document analysis. Semi-structured interviews explored participants' experiences and practices related to community-based natural resource management, while observations documented environmental conditions and community activities, and document analysis examined relevant village reports and policy documents. Table 1 summarizes the characteristics of the informants and their thematic contributions across the two study villages.

Table 1. Distribution of informants and their thematic contributions across study villages

Theme	Village	Informant Category	Number of Informants
Water management	Sukaraja	Farmers	4
	Way Panji	Farmers	4
	Sukaraja & Way Panji	Village officials	3
	Sukaraja & Way Panji	Community leaders	2
Adaptive agriculture	Sukaraja	Farmers	5
	Way Panji	Farmers	5
	Sukaraja & Way Panji	Agricultural extension officers	2
Land conservation	Sukaraja	Farmers	4
	Way Panji	Farmers	3
	Sukaraja & Way Panji	Community leaders	3
Human–environment relationship	Sukaraja	Community members	4
	Way Panji	Community members	4
	Sukaraja & Way Panji	Village elders	2

Interviews were conducted until thematic saturation was reached, and no new themes emerged from the data. After the twenty-first interview, the responses became repetitive; three additional interviews were conducted to confirm saturation, resulting in 24 interviews. Individual informants may have contributed to more than one thematic category; therefore, the frequencies presented do not represent unique participants. Field observations documented community practices, while document analysis examined village development plans and environmental reports. The triangulation of interviews, observations, and documents enhanced the credibility and trustworthiness of the findings.

Data were analyzed using manual thematic analysis. Interview transcripts, field observations, and documentary data were first reviewed to achieve data familiarization. Open coding was then used to identify meaningful statements related to community-based natural resource management, followed by axial coding to group related codes into broader categories. Selective coding integrated these categories into four overarching themes: (1) community-based water management, (2) adaptive agricultural practices, (3) land conservation strategies, and (4) human–environment relationships in local natural resource governance. To ensure trustworthiness, the findings were validated through data triangulation across interviews, observations, and documents, complemented by member checking with selected participants and iterative reviews of the coding process to enhance credibility and consistency. Ethical principles were observed throughout the study. All participants provided informed consent, participated voluntarily, and were informed of their right to withdraw at any time. Confidentiality and anonymity were maintained by removing identifying information from all research data.

3. Results and Discussion

3.1 Result

Thematic analysis generated four major themes related to community-based natural resource management and climate resilience. Table 2 summarizes the distribution of informants across the two study villages and their contributions to each theme. Individual informants contributed to one or more themes during the interviews. Individual informants may have contributed to more than one thematic category; therefore, the frequencies do not represent unique participants. The following sections present each theme in detail, supported by representative quotations from participants and interpreted in relation to community-based natural resource management and climate adaptation.

Table 2. Interview recap: Distribution of informants and their thematic contributions

Theme	Village	Informant Category	No. of Informants	Main Contributions
Community-Based Water Management	Sukaraja	Farmers	4	Irrigation scheduling, canal maintenance, and water allocation during dry seasons.
	Way Panji	Farmers	4	Collective irrigation management and equitable water-sharing arrangements.
	Sukaraja & Way Panji	Village officials	3	Coordination of irrigation governance, water-user groups, and local resource management.
Adaptive Agricultural Practices	Sukaraja & Way Panji	Community leaders	2	Conflict resolution and consensus-building in water management.
	Sukaraja	Farmers	5	Adjustment of planting schedules based on seasonal patterns.
	Way Panji	Farmers	5	Crop diversification, mixed farming systems, and climate-adaptive farming practices.
Community-Based Land Conservation	Sukaraja & Way Panji	Agricultural extension officers	2	Technical assistance and dissemination of climate-adaptive agricultural practices.
	Sukaraja	Farmers	4	Tree planting, terracing, and soil conservation.
	Way Panji	Farmers	3	Protection of water recharge areas and erosion control measures.
Human-Environment Relationships	Sukaraja & Way Panji	Community leaders	3	Community-based conservation initiatives and environmental stewardship.
	Sukaraja	Community members	4	Gotong royong, shared environmental responsibility, and stewardship values.
	Way Panji	Community members	4	Collective environmental management and protection of natural resources.
	Sukaraja & Way Panji	Village elders	2	Intergenerational transmission of environmental values and local ecological knowledge.

3.1.1 Community-based water management

Water availability is essential for sustaining agriculture and rural livelihoods in Rajabasa District. Although the area is generally supported by irrigation infrastructure, effective water governance remains crucial during the dry season. A key practice identified in this study is the collective regulation of irrigation water distribution among farmers.

Water allocation is coordinated through farmer groups or respected community leaders, who facilitate agreements on irrigation schedules to ensure equitable access and reduce the potential for conflict.. As one farmer stated:

"We don't drink water whenever we want. The irrigation schedule is agreed upon in the farmers' meeting so that every farmer receives a fair share, especially during the dry season." (Farmer, Interview 3)

Similarly, a village official emphasized the importance of collective coordination:

"If water distribution is not managed together, conflicts can easily occur. The farmer group first discusses the schedule, and everyone is expected to follow the agreement." (Village Official, Interview 3)

In addition to water allocation, local communities collectively maintain irrigation canals. Through periodic communal work activities (gotong royong), villagers remove sediment, vegetation, and waste that could obstruct water flow to agricultural fields. Community participation in these activities reflects a shared awareness of the importance of sustainable water resource management. As described by one community leader:

"Every planting season, we organize communal work to clean the canals. Everyone contributes because we understand that if the canals are blocked, all farmers will be affected." (Community Leader, Interview 1)

These interviews demonstrate that community-based irrigation management is sustained not only through formal institutional arrangements but also through shared norms of cooperation, collective responsibility, and mutual trust. Together, these mechanisms strengthen local adaptive capacity and contribute to village resilience to climate change. The following table presents the types of community-based water management activities undertaken, the actors, the implementation mechanisms, and their contributions to village resilience.

Table 3. Community-based water management activities in villages

No	Water Management Activity	Actors Involved	Implementation Mechanism	Objectives and Benefits
1	Regulation of irrigation water distribution	Farmer groups, water users (farmers), and community leaders	Water use scheduling based on collective agreements during the planting season	Ensures equitable water distribution among farmers and reduces the types of community-based water management activities
2	Maintenance of the irrigation canals	Village communities, farmer groups	Collective work (gotong royong) to clean irrigation channels from sediment, waste, and wild vegetation	Maintains smooth water flow to agricultural land
3	Maintenance and improvement of small-scale irrigation infrastructure	Farmers and village officials	Small embankments, simple water gates, and irrigation channels collectively repaired	Increases the efficiency of water distribution to agricultural fields
4	Protection of the spring water sources	Village communities, traditional leaders, and	Planting vegetation around springs and restricting activities that are	Ensures the long-term sustainability of the community's water availability

		community groups	environmentally damaging	
5	Water management for domestic needs	Village households and community groups	Shared utilization of water sources such as wells or village springs	Ensures the availability of water for household needs
6	Coordination among farmers during the dry season	Farmer groups and farmers	Deliberative meetings to determine water-use priorities when water discharge decreases	Reducing the risk of water shortages and strengthening social solidarity

The practices summarized in Table 3 demonstrate that community-based water management not only maintains water availability for agriculture but also strengthens social cohesion through cooperation, coordination, and shared responsibility. By fostering collective action and reducing the risk of resource-related conflicts, these practices enhance the community's adaptive capacity to cope with climate variability, thereby contributing to overall village resilience. This adaptive capacity also provides the foundation for other resilience strategies, particularly adaptive agricultural practices discussed in the following section.

3.1.2 Adaptive local agricultural practices

Changes in seasonal patterns and increasing climate uncertainty have become significant challenges for farmers in the Rajabasa area. Farmers have developed various adaptation strategies based on local knowledge to reduce the risk of crop failure. A commonly applied strategy is to adjust planting schedules based on experience and observations of weather conditions. Adaptive agricultural practices constitute another important dimension of community-based natural resource management in Rajabasa District. Farmers continuously adjust planting schedules, crop selection, and cultivation techniques in response to seasonal changes and variability in rainfall. These decisions are largely based on local ecological knowledge accumulated through long-term farming experience rather than relying solely on external information. One farmer described this adaptive process:

"We can no longer rely on the traditional planting calendar because the rainy season is becoming unpredictable. We observe rainfall patterns and soil conditions before deciding when to plant." (Farmer, Interview 2)

Another participant emphasized crop diversification as a strategy to reduce climate-related risks:

"Instead of planting only one crop, many farmers now combine rice, maize, and cassava. If one crop fails because of drought or pests, the others can still provide income." (Farmer Group Member, Interview 2)

A village agricultural extension officer also highlighted the importance of integrating local knowledge with technical advice:

"We encourage farmers to adopt improved cultivation techniques, but local knowledge remains essential because farmers understand the characteristics of their land better than anyone else." (Agricultural Extension Officer, Interview 1)

These findings indicate that adaptive agriculture in Rajabasa is a continuous learning process in which scientific recommendations and local ecological knowledge complement each other to strengthen livelihood resilience. The following table presents community-based adaptive agricultural practices, which support the discussion of farmers' adaptation

strategies in responding to changing seasonal patterns and climate uncertainty in Rajabasa District.

Table 4. Local knowledge-based agricultural adaptation practices in villages

No	Agricultural Adaptation Practice	Actors Involved	Implementation Mechanism	Objectives and Benefits
1	Adjustment of planting schedules	Farmers, farmer groups	Determining planting times based on observations of weather conditions, rainfall patterns, and soil conditions	Reduces the risk of crop failure caused by changes in seasonal patterns
2	Crop diversification	Farmers, farmer groups	Cultivating various commodities such as rice, maize, chili, vegetables, or other horticultural crops simultaneously or alternately	Reduces dependence on a single commodity and maintains farmers' income stability
3	Mixed farming systems	Farmers	Combining several types of crops within the same agricultural land	Improves land-use efficiency and maintains the balance of the agricultural ecosystem
4	Use of organic fertilizers	Farmers	Utilizing manure or compost as an alternative to chemical fertilizers	Maintains soil fertility and enhances the sustainability of agricultural production
5	Reduction use of chemical pesticide	Farmers	Using natural pesticides or mechanical pest control methods	Reduces environmental pollution and preserves soil health
6	Knowledge exchange among farmers	Farmers, farmer groups	Informal discussions, farmer group meetings, and sharing experiences in farming practices	Strengthens local knowledge and accelerates the dissemination of agricultural innovations

Table 4 shows that farmers in Rajabasa District have adopted locally based adaptation strategies to address climate variability, including adjusting planting schedules, crop diversification, mixed farming, and the use of organic fertilizers with reduced chemical pesticides. These practices demonstrate the adaptive capacity of rural communities to sustain agricultural productivity and environmental sustainability through local ecological knowledge. Together, these practices enhance the capacity of rural communities to adapt to climate variability while supporting sustainable agricultural production and long-term village resilience.

3.1.3 Community-based land conservation

In addition to water management and adaptive agricultural practices, rural communities also implement in various land management practices to sustain natural resources and reduce environmental degradation. These conservation efforts are carried out in response to several environmental problems, such as soil erosion, declining land fertility, and ecosystem degradation. Several conservation practices identified in this study include tree planting on degraded land, the construction of terraces on sloping terrain, and the use of ground-cover vegetation to reduce the risk of erosion. These activities are generally conducted through collaboration among farmer groups or through local community initiatives. As one community leader explained:

"The hills cannot be left bare because heavy rainfall causes erosion and landslides. We encourage every household to plant trees around their farmland." (Community Leader, Interview 2)

Similarly, a farmer stated:

"We preserve bamboo and other deep-rooted plants near the springs because they help maintain water availability during the dry season." (Farmer, Interview 1)

Another participant emphasized the long-term benefits of conservation:

"Protecting the land is not only for today's harvest but also for our children. If the soil is damaged, farming will become much more difficult in the future." (Village Elder, Interview 2)

This statement reflects the principle of intergenerational stewardship, in which land conservation is motivated not only by immediate agricultural productivity but also by a long-term commitment to preserving natural resources for future generations. Such a perspective reinforces the community's resilience by encouraging sustainable resource management that extends beyond short-term economic considerations. These accounts demonstrate that land conservation is viewed not merely as an environmental activity but also as a long-term investment in sustaining ecosystem services, securing agricultural livelihoods, and strengthening resilience to future climate-related disturbances. Community-based land conservation in Rajabasa extends beyond technical soil and vegetation management. The findings indicate that conservation practices are embedded in broader human–environment relationships, where collective values, social norms, and community cooperation shape how natural resources are managed. Therefore, the practices presented in Table 5 include both physical land conservation measures and the social mechanisms that sustain them, reflecting the inseparable relationship between ecological stewardship and community institutions.

Table 5. Land conservation practices and human–environment relationships in villages

No	Land Conservation Practice	Actors Involved	Implementation Mechanism	Objectives and Benefits
1	Planting erosion-control vegetation	Farmers, farmer groups, village communities	Planting trees or ground-cover vegetation on sloping land and along the edges of agricultural fields	Reduces soil erosion and maintains soil fertility
2	Sustainable management of sloping land	Farmers	Constructing simple terraces or arranging planting patterns following the natural land contours	Prevents land degradation and improves soil stability
3	Protection of water recharge areas	Village communities, community leaders	Restricting activities that may damage water sources and planting vegetation around recharge areas	Ensures the sustainability of water sources for communities and agriculture
4	Community environmental work (collective labour)	Village communities, youth groups, village officials	Collective activities (gotong royong) to clean the environment, water channels, and agricultural areas	Improves environmental quality and strengthens social solidarity
5	Tree planting on agricultural land or home gardens	Farming households, community groups	Planting productive or protective trees around agricultural land	Maintains ecosystem balance and increases vegetation diversity

The table 5 indicates that land conservation practices in the villages of Rajabasa District are implemented not only through technical land management measures but also

through various social activities that involve community participation. The findings suggest that community-based land conservation in Rajabasa is sustained not merely by individual conservation practices but by the integration of ecological stewardship and collective social action. Rather than functioning as isolated activities, conservation measures are embedded in shared norms, mutual cooperation, and long-standing community participation, which reinforce compliance and encourage the sustainable use of natural resources. This integration enables local communities to maintain ecosystem functions while strengthening their adaptive capacity to cope with environmental change. Consequently, land conservation serves not only as an ecological strategy but also as a governance mechanism that enhances long-term community resilience.

3.1.4 Human–environment relationships in community practices: Overall synthesis

The relationship between rural communities and the environment has strong social and cultural dimensions. In everyday life, communities view nature as a vital source of livelihood that must be preserved to ensure its sustainability. This perspective is reflected in various social practices such as mutual cooperation (*gotong royong*), communal work activities, and other collective initiatives related to environmental management. The findings reveal that the relationship between rural communities and the environment is shaped by strong social and cultural values. Participants viewed natural resources as shared assets that sustain livelihoods and should therefore be managed collectively for the benefit of both present and future generations. These values are reflected in everyday practices such as *gotong royong*, communal environmental activities, and adherence to local environmental norms. One village elder remarked:

"Nature provides our livelihood, so we must take care of it. If we damage *the forest or the springs*, we will suffer the consequences ourselves." (Village Elder, Interview 4)

A community member expressed a similar perspective:

"Looking after the environment is part of our daily life. We teach our children not to cut trees carelessly because water and fertile land are our future." (Community Member, Interview 3)

Another participant emphasized the collective dimension of environmental stewardship:

"Environmental conservation cannot be done individually. Everyone has to participate because we all depend on the same land and water resources." (Village Official, Interview 3)

These findings suggest that environmental stewardship in Rajabasa is embedded in shared social values and collective responsibility, creating a strong social foundation for adaptive governance and long-term climate resilience. The following table presents a synthesis linking natural resource management practices with dimensions of village resilience to climate change in Rajabasa District. Table 6 demonstrates that village resilience emerges from the interaction of complementary natural resource management practices rather than from individual interventions. Ecological management, adaptive farming, and collective resource governance reinforce one another to enhance the community's capacity to anticipate, respond to, and recover from climate-related challenges. Beyond protecting natural resources, these interconnected practices strengthen livelihood security, reduce vulnerability, and build long-term adaptive capacity, illustrating how community-based natural resource management functions as an integrated resilience strategy. These findings suggest that village resilience is determined not only by the availability of natural resources but also by the social and institutional capacity of communities to collectively manage these resources.

Table 6. The Relationship between Natural Resource Management Practices and Village Resilience to Climate Change in Rajabasa District

No	Natural Resource Management Practice	Forms of Activities at the Village Level	Dimensions of Village Resilience Strengthened	Impact on Climate Change Adaptation
1	Community-based water management	Regulation of irrigation water distribution, maintenance of water channels, protection of spring water sources	Ecological and social resilience	Maintaining water availability during the dry season and strengthening cooperation among farmers
2	Adaptive agricultural practices	Adjusting of planting schedules and using local knowledge regarding seasonal patterns	Economic and food production resilience	Reduces the risk of crop failure caused by changing seasonal patterns
3	Crop diversification	Cultivation of various agricultural commodities within a single production cycle	Household economic resilience	Maintains farmers' income stability when one commodity's production declines
4	Environmentally friendly agriculture	Use of organic fertilizers and reduction of chemical pesticide use	Ecological resilience	Maintains soil fertility and the sustainability of agricultural systems
5	Land conservation	Planting erosion-control vegetation and managing sloping land	Environmental resilience	Reduces land degradation and maintains agricultural productivity
6	Community institutions	Role of farmer groups and village deliberations in natural resource management	Social and institutional resilience	Strengthens coordination and the capacity of the community to respond to environmental crises

3.2 Discussion

The findings show that Community-Based Natural Resource Management (CBNRM) strengthens village resilience through integrated water management, adaptive agriculture, land conservation, and local institutions. These findings extend CBNRM, contribute to the Social-Ecological Systems (SES) perspective by emphasizing the interaction between ecological knowledge and collective action, and refine Adaptive Governance theory by highlighting the roles of informal institutions and social learning in climate adaptation.

3.2.1 Community-based water management as a form of common-pool resource governance

The community-based water management identified in this study can be understood as a form of common-pool resource management regulated through social mechanisms and local institutions. In this context, rural communities develop systems for irrigation water distribution, irrigation canal maintenance, and the protection of spring water sources through collective cooperation between farmer groups and community leaders (Safkat & Jafor, 2025; Ziem Bonye et al., 2022). According to Ostrom (2009), locally agreed rules, social monitoring mechanisms, and community participation in decision-making processes typically support the effective management of common-pool resources (McClanahan & Abunge, 2019; Slough et al., 2021). The findings of this study reflect these principles, particularly through practices such as irrigation scheduling, deliberative meetings among farmers, and collective labor (*gotong royong*) in maintaining irrigation canals. However, The findings build upon Ostrom's common-pool resource framework by showing that

community-based water governance contributes not only to preventing resource overuse but also to strengthening climate adaptation through resource allocation, ecosystem maintenance, and collective learning.

From a broader perspective, community-based water management can also be viewed as part of adaptive governance, a governance approach model capable of responding to environmental change through social learning and collaboration among multiple actors (Folke et al., 2016). In the Rajabasa context, the presence of farmer groups and village deliberation mechanisms enables communities to adjust water resource management according to seasonal conditions and agricultural needs. Several studies have also suggested that community-based water management can improve water distribution efficiency while strengthening local social solidarity (Beyonyi & Ile, 2023; Leroy, 2023). This is evident in the practice of collective irrigation maintenance, which not only ensures a smooth flow of water but also reinforces social relationships among farmers. Therefore, community-level water management possesses not only ecological dimensions, but also important social dimensions that contribute to strengthening village resilience. These findings reinforce the Social-Ecological Systems perspective by demonstrating that ecological resilience depends on interactions between environmental resources and community institutions rather than on biophysical conditions alone. Likewise, they illustrate the Adaptive Governance perspective by showing how trust, informal norms, and collective action enable communities to adjust resource management in response to changing climatic conditions.

3.2.2 Adaptive agricultural practices and the role of local knowledge

The findings further indicate that farmers in Rajabasa District have developed a range of locally grounded agricultural adaptation strategies in response to changing seasonal patterns. Adjustments to planting schedules, crop diversification, and the implementation of mixed farming systems represent examples of adaptive strategies derived from farmers' experiences and observations of environmental conditions. Local knowledge is often regarded as a crucial resource for enhancing community adaptive capacity in studies of rural development and climate change (Adger et al., 2021). Such knowledge is typically formed through long-term interactions between communities and their environments, providing relevant insights into seasonal variations, soil conditions, and local ecosystem dynamics (Varah & Varah, 2022). These findings build on the CBNRM literature by demonstrating that local ecological knowledge functions not only as a source of environmental information but also as a governance resource that supports collective decision-making and adaptive resource management under climate uncertainty.

Crop diversification practiced by farmers in Rajabasa can be understood as a proactive risk management strategy to reduce vulnerability to climate variability, pest outbreaks, and crop failure while stabilizing household livelihoods. By cultivating multiple crop types, farmers spread production risks and enhance the resilience of their agricultural systems. This interpretation is consistent with previous studies showing that agricultural systems with greater crop diversity are more resilient to environmental disturbances, including climate change and pest outbreaks (Dardonville et al., 2020, 2022). Crop diversification enables farmers to reduce their dependence on a single commodity while maintaining stability in both production and income. Furthermore, the use of organic fertilizers and reduction of chemical pesticide use reflect an orientation toward sustainable agriculture. Agroecology emphasizes the integration of agricultural practices with ecological principles in order to maintain land productivity while protecting the environment (Altieri, 2019; Yadav, 2025). The adoption of environmentally friendly agricultural practices indicates an increasing awareness among local communities of the importance of maintaining soil fertility in the long term. These findings contribute to the Social-Ecological Systems (SES) perspective by showing that adaptive agricultural practices emerge through the reciprocal interaction between ecological conditions, local knowledge, and community learning processes. Moreover, this study also illustrates Adaptive Governance theory by showing that agricultural adaptation is sustained not only through

formal extension services but also through continuous local experimentation, knowledge sharing, and collective learning among farmers. Consequently, adaptive agriculture in Rajabasa functions as both a livelihood strategy and an institutional mechanism that strengthens coastal rural communities' long-term climate resilience.

3.2.3 Land conservation as a strategy for to maintain ecosystem sustainability

The findings of this study indicate that the land conservation practices carried out by the rural communities in Rajabasa District reflect a collective awareness of the importance of maintaining the ecological functions of the environment. Various efforts—such as planting erosion-control vegetation, managing sloping land, and protecting water recharge areas—represent local adaptations to the risks of land degradation and declining agricultural productivity. These practices are intended not only to protect the environment but also to sustain the livelihoods of communities that depend heavily on agriculture. Community-based conservation is widely regarded as an effective approach for maintaining Previous studies have shown that community-based conservation is more effective when local communities actively participate in planning, implementing, and monitoring environmental management. The Rajabasa case supports this perspective by demonstrating that conservation practices are embedded in everyday community activities rather than being driven solely by formal regulations (Fariss et al., 2023; Measham & Lumbasi, 2013). In other words, the ability of local communities to integrate economic interests with environmental protection efforts strongly influences ecosystem sustainability. These findings build on the CBNRM literature by demonstrating that conservation practices function not only to protect ecological resources but also as collective governance mechanisms that simultaneously sustain ecosystem services, agricultural livelihoods, and long-term climate resilience.

Moreover, the conservation practices in Rajabasa can also be understood from the perspective of social-ecological systems, which emphasizes the close interconnection between human activities and ecosystem dynamics (Folke et al., 2016). Within this framework, environmental sustainability largely depends on communities' adaptive capacity to adjust resource management practices in response to changing ecological conditions (Chen et al., 2023). In Rajabasa, land conservation is manifested not only through technical measures, such as terracing or planting of vegetation but also through social norms that regulate environmental use. For instance, informal community agreements exist to protect certain areas around water sources from excessive exploitation. This indicates that social and cultural values play an important role in strengthening community-based conservation while maintaining the sustainability of social-ecological systems at the village level (Berman et al., 2012). These findings illustrate the Social-Ecological Systems perspective by demonstrating that ecological resilience emerges through interactions among local ecological knowledge, community institutions, and collective action.

3.2.4 Human-environment relationships in community-based governance

The findings also show that the relationship between humans and the environment in Rajabasa District villages is not solely economic in nature but also encompasses strong social and cultural dimensions. Local values, such as gotong royong (cooperation), solidarity, and shared responsibility, serve as the main foundation for shaping various forms of community cooperation in natural resource management. These values are reflected in village communities' collective activities, such as irrigation maintenance, shared water resource management, and participatory environmental conservation practices (Anyanwu et al., 2025; Musavengane & Simatele, 2016). From a theoretical perspective, this relationship can be explained through the concept of community environmental governance, a system of environmental governance that positions communities as the primary actors in natural resource management (Bodin, 2017; Delgado et al., 2019). This approach emphasizes that effective environmental management depends not only on

formal policies or government interventions but also on the collective capacity of communities to organize joint action. It also highlights the importance of locally developed rules and compliance with evolving social norm (Slikkerveer, 2019). These findings build on the Community-Based Natural Resource Management (CBNRM) literature by demonstrating that cultural values and social capital are not merely supporting factors but constitute core governance mechanisms that sustain collective resource management and strengthen long-term resilience.

In the context of this study, the presence of local institutions, particularly farmer and resource-user groups, strengthens such collective capacity. These institutions function as platforms for social coordination that enable communities to regulate access to resources, resolve potential conflicts, and build cooperation in environmental management. Local institutions play a strategic role in establishing collectively agreed rules for resource use and ensuring the long-term sustainability of resource management (Ratner et al., 2017). These findings show that resilience emerges through the interaction of social norms, local institutions, ecological stewardship, and collective action, highlighting that adaptive governance depends on institutional flexibility and community capacity to sustain ecosystem resilience (Celata & Sanna, 2019; Rahman, 2025).

3.2.5 Community-based natural resource management and village resilience

Overall, the findings of this study indicate that community-based natural resource management practices in Rajabasa District make a significant contribution to strengthening village resilience to climate change. Rather than functioning independently, these practices collectively enhance the capacity of rural communities to anticipate, respond to, and recover from climate-related disturbances (Chen et al., 2023; Shapna et al., 2024). Through collective water management, communities are able to maintain the availability of water resources for both domestic and agricultural needs (Celata & Sanna, 2019). Simultaneously, adaptive agricultural practices—such as adjusting planting schedules, crop diversification, and the use of local ecological knowledge—enable farmers to respond to changing seasonal patterns and climate uncertainty. Land conservation efforts, such as planting erosion-control vegetation and protecting water recharge areas, play a crucial role in maintaining ecosystem stability, which forms the basis for the sustainability of rural livelihoods (Reid, 2016). These findings build on the CBNRM literature by demonstrating that village resilience is generated through the integration of multiple community-led resource management practices rather than through isolated sectoral interventions.

From the perspective of social–ecological systems, resilience refers to a system’s ability to adapt, absorb disturbances, and maintain its core functions when facing environmental pressures (Adger & Hobdod, 2014; Cinner & Barnes, 2019). Village resilience is reflected in the ability of communities to adjust natural resource management practices in response to environmental dynamics without undermining the sustainability of production systems and social life (Li et al., 2020; Stokols et al., 2013). Such adaptation is therefore not only a technical process but also a social and institutional process supported by community organizations, shared norms, and collective decision-making. These findings illustrate to the SES perspective by showing that resilience emerges through the interaction of ecological knowledge, local institutions, and collective action. They also demonstrate Adaptive Governance theory by highlighting the roles of community participation, social norms, and collective learning in strengthening climate resilience in disaster-prone coastal villages.

This study contributes to the literature on CBNRM, SES, and Adaptive Governance by showing that resilience is strengthened in disaster-prone coastal communities through the interaction of local ecological knowledge, community institutions, collective action, and locally embedded social norms. Strengthening climate resilience in coastal communities requires the integration of community-based natural resource management into adaptation policies and village planning. To enhance sustainable rural development and long-term resilience, this should be supported by participatory governance, local institutions, and climate-resilient practices grounded in local ecological knowledge.

This study is limited by its qualitative single-case design, which focuses on villages in Rajabasa District, restricting the generalizability of the findings. In addition, the analysis relies on qualitative data without incorporating quantitative measures of adaptive capacity or resilience and captures community adaptation at a single point in time rather than over longer periods. Future studies should examine community-based natural resource management across multiple coastal regions using comparative and mixed-methods approaches to validate the proposed framework. Furthermore, future research should investigate the role of digital technologies, climate information services, and multi-level governance in strengthening community-based climate adaptation.

4. Conclusions

This study demonstrates that community-based natural resource management (CBNRM) practices implemented in the villages of Rajabasa District, South Lampung Regency, represent an effective and integrated local governance mechanism for strengthening village resilience to climate change. In addressing the first research question, the findings show that community-based natural resource management in Rajabasa is characterized by integrated water management, adaptive agricultural practices, and collective land conservation. Together, these practices demonstrate how local communities organize and manage natural resources through collaboration, local ecological knowledge, and shared responsibility to respond to climate-related challenges.

In response to the second research question, the study shows that these interconnected resource management practices substantially contribute to village resilience by ensuring water availability, enhancing agricultural productivity, reducing environmental degradation, and sustaining ecosystem services essential for long-term community well-being. Importantly, resilience is reinforced by strong local institutions, the cultural value of gotong royong (mutual cooperation), collective norms, and continuous social learning that enable communities to organize, coordinate, and respond effectively to environmental uncertainty. These findings build on the Community-Based Natural Resource Management, Social-Ecological Systems, and Adaptive Governance literature by demonstrating that village resilience emerges from the dynamic interaction of ecological knowledge, collective action, informal institutions, and locally embedded social values rather than isolated sectoral interventions. Consequently, climate adaptation policies in coastal rural areas should complement infrastructure development with investments in community capacity, stronger local institutions, participatory governance, and the integration of local ecological knowledge into sustainable natural resource management.

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Author Contribution

Conceptualization: S.S.H.; Methodology: S.S.H., and D.H.; Data Collection: S.S.H., and D.H.; Investigation: D.H.; Formal Analysis: D.H.; Writing—Original Draft Preparation: S.S.H.;

Writing—Review and Editing: D.H.; Proofreading: D.H.; Project Administration: D.H. All authors have read and agreed to the published version of the manuscript.

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Ethical Review Board Statement

Ethical review and approval were waived for this study because the research involved minimal risk and focused on qualitative interviews and observations related to community-based natural resource management. The study did not involve sensitive personal data, medical procedures, or vulnerable populations. Participation was voluntary, and the confidentiality and anonymity of all participants were ensured throughout the research process.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. All participants were informed about the purpose of the research, the voluntary nature of their participation, and their right to withdraw from the study at any time.

Data Availability Statement

The data supporting the findings of this study are not publicly available due to privacy and ethical considerations, as the dataset contains interview transcripts and field notes that may reveal the identity of research participants. However, limited data may be available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest. The funder had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT to assist in improving grammar, clarity, and academic language of the manuscript. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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