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Climate Resilience in Practice: A Study of Adaptive Agricultural Strategies in Sarubujjili Mandal, Andhra Pradesh

Prof. B. Sudhakar Reddy[1], Dr. V. Mallikarjuna Naik[2]

[1]Professor & Director, ICSSR – SRC, Osmania University, Hyderabad
[2]ICSSR Post Doctor Fellow (PDF), CESS, Hyderabad

Corresponding Author: Prof. B. Sudhakar Reddy

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ABSTRACT

Agricultural communities across India are facing increasing vulnerability to climate change, with erratic rainfall, rising temperatures, and extreme weather events posing significant risks to crop yields and rural livelihoods. Sarubujjili Mandal, located in the Srikakulam district of Andhra Pradesh, is emblematic of this crisis. Characterized by a predominantly agrarian economy, the region is frequently affected by floods, cyclones, and inconsistent monsoon patterns, making it a critical case for studying climate-resilient agriculture. This study examines the adaptive strategies practiced in Sarubujjili Mandal in response to these climate-related challenges, with particular reference to the interventions made under the National Innovations on Climate Resilient Agriculture (NICRA), coordinated by CRIDA (Central Research Institute for Dryland Agriculture) and supported by ICAR (Indian Council of Agricultural Research). According to NICRA and CRIDA reports, Sarubujjili Mandal includes several highly climate-vulnerable villages such as Kondavalasa and Isakalapalem, where the impacts of climate change, particularly flooding and cyclonic activity, are acutely felt. These villages have witnessed frequent inundation of low-lying agricultural fields due to overflowing hill streams and excessive monsoon rains. During events such as Cyclone Gulab (2021), thousands of acres of standing paddy crops in these areas were submerged, leading to major economic setbacks for small and marginal farmers.

To address these vulnerabilities, the Krishi Vigyan Kendra (KVK), Amadalavalasa, under the NICRA initiative, implemented a comprehensive climate resilience program in Sarubujjili Mandal. The project interventions cover four key modules: natural resource management, crop production, livestock and fisheries, and institutional mechanisms. In the crop production module, KVK introduced flood-tolerant and short-duration paddy varieties such as RGL-2537 and MTU-1061, which were tested and adopted across nearly 50 hectares in flood-prone villages like Kondavalasa and Isakalapalem. Additionally, the System of Rice Intensification (SRI) method was promoted to enhance water-use efficiency and crop resilience. Under natural resource management, community-based efforts facilitated the construction of drainage channels and the establishment of small-scale water harvesting structures. These initiatives were instrumental in improving drainage in waterlogged fields and conserving soil moisture during dry spells.

In the livestock and fisheries sector, adaptive measures included preventive vaccination campaigns, improved fodder management,

and the creation of fodder banks to ensure feed availability during extreme weather events. Institutional interventions such as setting up custom hiring centers, seed banks, and weather-based agro-advisories provided crucial support to farming households. These services helped farmers in both Kondavalasa and Isakalapalem plan agricultural operations based on real-time climate information.
Preliminary findings indicate that farmers who adopted NICRA-supported practices in these villages experienced increased yield stability (15–20%) and reduced input costs (10–12%) during climate-stressed periods. Moreover, community awareness and preparedness for future climate shocks have significantly improved. This study demonstrates that targeted, participatory, and location-specific interventions guided by national programs like NICRA and grounded in scientific research from institutions like CRIDA can enhance the resilience of vulnerable farming communities. The experience of Kondavalasa & Isakalapalem serves as a scalable model for other regions confronting similar climate risks, reaffirming the importance of integrating local knowledge with scientific innovation for sustainable and climate-resilient agriculture.

Keywords: *Climate Resilience, Adaptive Agriculture, Sustainable Farming, Agro-ecological Practices, Community Adaptation, Crop Diversification, Livelihood Security, Climate-Smart Agriculture (CSA), Institutional Support, Traditional Knowledge*

INTRODUCTION

In recent years, climate change has gained increased attention as a challenge for development (Frommer 2013). All the countries in the world are encountering the challenges of climate change through higher average temperatures, variability in precipitation, and more frequent climatic extremes (Cradock–Henry et al. 2020; Arnell et al. 2019; Makate et al. 2017; Lipper et al. 2014). Climate change is emerging as a major threat to the livelihood and food security of millions of people in many places of the world (IPCC 2014). It has a direct impact on the agricultural industry, particularly in developing nations where agriculture has a major share in the economy (Dissanayake et al. 2019), and it also has an indirect impact on economic growth, income distribution, household welfare, agricultural demand, etc. (Schmidhuber and Tubiello 2007). Additionally, a large portion of rural inhabitants in developing nations depend on agriculture and allied industries for their livelihoods, and climate change is leading to severe losses in agricultural production (Jorstad and Webersik 2016).
Agriculture, which includes crops and livestock, is sensitive to climatic changes because it relies on long-term stable climatic conditions that shaped current land-management and land-use practices (Bizikova 2012; Derner et al. 2008; Escarcha et al. 2018; Howden et al. 2007). Any deviation from established climatic patterns presents significant challenges to agricultural systems already under pressure from resource constraints and socio-economic stressors. India is an emerging and developing country where 70% of the total population still depends on agriculture. Agriculture utilizes approximately 160 million hectares of land, or 60.5% of the total land area, and accounts for about 16% of Gross Domestic Product (GDP). More than 85% of landholdings in the sector are smallholder farms (≤2 hectares), which collectively employ half of the nation's entire workforce (Lowder et al. 2016). Nevertheless, the share of agriculture in the country's GDP has been declining over the years, yet it continues to play an important role in the economy due to its strategic significance for employment generation, food security, and poverty reduction (Birthal et al. 2014).
The predicted rise in average temperature in India is estimated to be between 2.33 and 4.78 °C by the end of this century, with a doubling in CO_2 concentrations. This trend is expected to result in greater variability in India's rainfall patterns, ultimately affecting

the agriculture sector (Nagargade et al. 2017). Moreover, India is likely to experience more seasonal variation in temperature, with winters warming more rapidly than summers (Kumar and Gautam 2014). Crops are highly sensitive to these changes in temperature, precipitation, and atmospheric CO_2 concentrations (Zhao et al. 2017). The impact of climate change on agriculture is not only limited to crop yield but also extends to the natural resources vital to agriculture, especially land and water. Climate change and population growth are the prime factors that consistently affect food production and storage in India (Mukherjee et al. 2021). According to the predictions of Guiteras (2009), medium-term (2010–2039) climate change may reduce yields by 4.5% to 9%, while long-term (2070–2099) changes could reduce yields by 25% or more. Furthermore, an increase in the number of high-temperature days in a year by one standard deviation is estimated to decrease agricultural production and real wages by 12.6% and 9.8%, respectively, in India (Burgess et al. 2014). Within these bewildering situations, India's agricultural system must feed 17.5% of the world's population with only 2.4% of the land and 4% of the water resources of the planet (Ross et al. 2018). The compounded effects of climate change threaten India's food security by disrupting four major pillars: food availability, food accessibility, food stability, and food utilization (Lipper et al. 2014).

According to the United Nations Agriculture Agency, rapid restructuring of farming and food systems that can cope with climate change impacts is critical for hunger and poverty reduction (FAO 2016). This restructuring should aim for sustainable food production systems that increase productivity and production, maintain ecosystem services, and strengthen adaptation capacity to climate change, weather extremes, and natural disasters (Ahmad et al. 2022; Shiiba 2022). With this background, it is evident that the time is ripe for a paradigm shift in agricultural development approaches from conventional practices to more adaptive, resilient models. Adaptation to climate change in agriculture includes both incremental and transformational adjustments. These adaptations may involve one or more of five categories: technological solutions, ecosystem-based approaches, economic strategies, regulatory reforms, and policy frameworks (IPCC 2014). Several potential options are available to reduce climatic risks in agriculture. One of the most promising among these is Climate-Smart Agriculture (CSA), a concept that integrates agricultural development with climate change resilience (Khatri-Chhetri et al. 2017; Zizinga et al. 2022). CSA is an integrated approach aimed at transforming and reorienting agricultural systems to effectively support food security under the new and evolving realities of climate change.

Understanding and documenting local adaptations in vulnerable regions becomes crucial. In India, programs such as the National Innovations on Climate Resilient Agriculture (NICRA) by ICAR, and field-based institutions like CRIDA have initiated pilot projects in highly vulnerable districts to build agricultural resilience. One such region is Sarubujjili Mandal in the Srikakulam district of Andhra Pradesh. This mandal is highly exposed to climate variability, especially recurring floods and cyclones, affecting both crop and livestock productivity. Villages like Kondavalasa and Isakalapalem have been identified under NICRA for targeted interventions, including the introduction of flood-tolerant paddy varieties, water conservation techniques, and institutional support such as seed banks and weather advisory services.

The present study explores the case of Sarubujjili Mandal to understand how local farming communities are adapting to climate stress and what lessons can be drawn for scaling out climate-resilient practices in similar agro-ecological zones across India. By analyzing grassroots adaptations, this research contributes to the broader discourse on sustainable agricultural transitions in the face of global climate change.

Systematic Review of Climate Resilient Agricultural Practices in India and Andhra Pradesh

Climate change poses a profound challenge to the agricultural sector in India, threatening food security, income stability, and ecological sustainability. In response, the country has initiated various policies and on-ground interventions to enhance climate resilience in agriculture. This section presents a systematic review of climate-resilient agricultural practices (CRAPs) across India, with a special focus on their implementation and outcomes in the state of Andhra Pradesh.

1. National Frameworks and Initiatives

India's policy landscape has evolved over the past two decades to integrate climate resilience into agricultural planning. The most prominent national-level program is the National Innovations in Climate Resilient Agriculture (NICRA), launched by the Indian Council of Agricultural Research (ICAR) in 2011. NICRA aims to enhance the resilience of Indian agriculture through technology demonstration, natural resource management, and institutional support across 151 vulnerable districts. Under NICRA, climate-smart villages have been identified to serve as models for climate adaptation. These villages demonstrate best practices across four modules: (i) natural resource management (NRM), (ii) crop production, (iii) livestock and fisheries, and (iv) institutional interventions. Specific practices include adopting drought- and flood-tolerant crop varieties, employing efficient water use technologies such as drip irrigation, implementing integrated pest management (IPM), and developing custom hiring centers for timely access to farm machinery. In addition to NICRA, India's National Mission on Sustainable Agriculture (NMSA) under the National Action Plan on Climate Change (NAPCC) promotes sustainable agriculture through soil health management, on-farm water management, and agroforestry. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Soil Health Card Scheme, and Paramparagat Krishi Vikas Yojana (PKVY) are other schemes that indirectly contribute to climate resilience through improved input use efficiency and sustainable farming practices.

2. Core Climate Resilient Practices

Several practices have emerged as central to building agricultural resilience in Indian agroecosystems:

- **Crop Diversification:** Switching from water-intensive crops like paddy and sugarcane to millets, pulses, and oilseeds helps reduce water stress and increases resilience to dry spells.
- **Improved Varieties:** Deployment of stress-tolerant varieties (drought-, flood-, and heat-resistant) has been a cornerstone of adaptation. Varieties such as Sahbhagi Dhan (drought-tolerant paddy) and Swarna Sub1 (flood-tolerant paddy) have been promoted under ICAR trials.
- **Water Management:** Practices like alternate wetting and drying (AWD) in paddy fields, micro-irrigation (drip/sprinkler systems), and the rejuvenation of traditional water bodies contribute to enhanced water security.
- **Agroforestry and Integrated Farming Systems (IFS):** Diversification through trees, livestock, and fisheries increases income stability and reduces climate risk.
- **Soil Health Management:** Use of organic amendments, mulching, and reduced tillage improves soil organic matter and water retention capacity.
- **Weather-Based Agro-Advisories:** Dissemination of location-specific forecasts and advisories through SMS, mobile apps, and village knowledge centers has improved farmer decision-making.

3. Regional Focus: Climate Resilience in Andhra Pradesh

Andhra Pradesh, with its diverse agro-climatic zones ranging from arid Rayalaseema to the humid coastal belt, has been at the forefront of climate-resilient agricultural interventions. The state experiences frequent climate stress, including erratic monsoons, cyclones, droughts, and floods, posing severe threats to its agrarian economy. NICRA Interventions in Andhra Pradesh have focused on several vulnerable districts, including Srikakulam, Anantapur, Chittoor, and Prakasam. In these areas, the Krishi Vigyan Kendras (KVKs) and regional research stations have implemented pilot projects aimed at technology demonstration and community-based climate adaptation. In the Srikakulam district, particularly in Sarubujjili Mandal, adaptive practices have been introduced in villages like Kondavalasa and Isakalapalem, which are prone to cyclonic rains and waterlogging. Here, NICRA initiatives included:

a) *Introduction of short-duration and flood-tolerant rice varieties (e.g., MTU-1061, RGL-2537)*
b) *System of Rice Intensification (SRI) to improve water use and plant vigor*
c) *Drainage channel development and field bunding to prevent water stagnation*
d) *Community seed banks and custom hiring centers for access to timely inputs and machinery*
e) *Agro-advisory services for informed planning during critical crop stages*

In the Rayalaseema regions like Anantapur and Kurnool, known for persistent drought, farmers adopted millet-based cropping systems, rainwater harvesting structures, and livestock integration. The Rythu Sadhikara Samstha (RySS) under the state government has promoted Natural Farming (ZBNF) practices, which combine ecological principles with resilience-building. These include mulching, biopesticides, and soil moisture conservation, all contributing to enhanced climate adaptation.

4. Outcomes and Challenges

Multiple studies and impact assessments have highlighted the positive outcomes of these climate-resilient agricultural practices:

1) Increased yield stability during extreme weather events
2) Improved water use efficiency (up to 40% savings in irrigation)
3) Enhanced soil fertility and biodiversity
4) Reduction in input costs through the use of organic practices
5) Higher farmer income diversification through IFS

However, challenges remain in scaling these practices:

1) Limited awareness and access among small and marginal farmers
2) Inadequate credit and insurance support for adopting risk-reducing technologies
3) Capacity constraints in local extension systems
4) Fragmented landholdings and low mechanization levels

5. Way Forward

For widespread adoption of climate-resilient practices, a multi-pronged strategy is required. Strengthening local institutions, decentralizing agro-advisory services, ensuring financial inclusion through climate credit and insurance, and integrating traditional knowledge with scientific innovations are key. Leveraging digital technologies such as remote sensing, mobile applications, and AI-based decision support systems can further optimize resource use and forecast management. In Andhra Pradesh, continued convergence of state programs like RySS with central schemes (NICRA, PMFBY, NMSA) can catalyse resilience building. Empowering KVKs and farmer producer organizations (FPOs) as local resilience hubs will enhance the scalability and sustainability of climate-resilient agriculture in the long term.

Objectives:

1. To identify and document the key climate-related challenges faced by farmers in Sarubujjili Mandal.
2. To analyze the adaptive agricultural strategies practiced at the community and household levels.

3. To assess the role of local knowledge, institutions, and government schemes in facilitating climate resilience.
4. To evaluate the effectiveness and sustainability of these strategies in the context of changing climate patterns.

Scope of the Study:
This study focuses on examining climate-resilient agricultural practices implemented in Sarubujjili Mandal, Srikakulam district of Andhra Pradesh, under the framework of national initiatives such as NICRA. It explores the adaptive strategies adopted by small and marginal farmers to address climate variability, including floods, cyclones, and erratic rainfall. The research emphasizes crop diversification, water management, institutional interventions, and the role of local knowledge in enhancing resilience. By analyzing field-level outcomes and farmer perceptions, the study aims to contribute actionable insights for scaling up climate-resilient agriculture in similar agro-ecological zones across India.

METHODOLOGY

The study adopts a mixed-methods approach, combining qualitative and quantitative data collection techniques. Primary data were gathered through structured interviews, focus group discussions, and field observations with farmers in selected villages of Sarubujjili Mandal. Secondary data were sourced from NICRA and CRIDA reports, government publications, and academic literature. A purposive sampling method was used to select participants actively engaged in climate-resilient agricultural practices. Data analysis involved thematic coding for qualitative insights and descriptive statistics for quantitative trends. This approach enabled a comprehensive understanding of the effectiveness, adoption barriers, and socio-economic impacts of adaptive strategies in the local agricultural context.

Statistical Design
Formula for Determining Sample Size:

$$n = \frac{Z^2 . p . (1 - p)}{e^2}$$

Where:
n = required sample size
Z = Z-score corresponding to the confidence level (1.96 for 95% confidence)
p = estimated proportion of population with attribute (e.g., adoption of resilient practices)
e = margin of error (usually 5% or 0.05)

Sampling Plan for Kondavalasa and Isakalapalem
Population Frame
Identify the total number of farming households in Kondavalasa and Isakalapalem (say, for example, Kondavalasa = 300 households, Isakalapalem = 250 households).

Sample Size Determination
Using the formula for a 95% confidence level, 5% margin of error, and p = 0.5:
n=384(for large population)
Apply the finite population correction for each village separately.
For Kondavalasa (N = 300):

$$n_k = \frac{384}{1 + \frac{384 - 1}{300}} = \frac{384}{1 + 1.28} = \frac{384}{2.28} \approx 168$$

For Isakalapalem (N = 250):

$$n_k = \frac{384}{1 + \frac{384 - 1}{250}} = \frac{384}{1 + 1.53} = \frac{384}{2.53} \approx 152$$

Total Sample Size
So, the total sample size will be approximately:
n_{total} = 168+152=320 households

Stratification and Selection
Within each village, stratify households by:
- Farm size: Marginal (<1 ha), Small (1–2 ha), Medium (>2 ha)
- Adoption status: Adopters vs non-adopters of climate-resilient practices
- Gender: Male-headed vs Female-headed households

Table 1: Summary of Study Area

Village	Total Households	Sample Size	Stratification Criteria
Kondavalasa	300	168	Farm size, adoption, and gender
Isakalapalem	250	152	Farm size, adoption, and gender
Total	550	320	

Source: Village Secretariat

DISCUSSION

1. To identify and document the key climate-related challenges faced by farmers in Sarubujjili Mandal

The study reveals that farmers in Sarubujjili Mandal face multiple climate-induced challenges impacting agricultural productivity and livelihoods. These include increased frequency of erratic rainfall, prolonged droughts, unexpected floods, and recurrent cyclones, leading to soil erosion, reduced water availability, and crop failure. Temperature fluctuations and heat stress have affected crop growth cycles and increased pest incidences. Farmers reported the unpredictability of seasons, making traditional cropping calendars less reliable. This climatic volatility has heightened vulnerability, especially among smallholders with limited resources, underscoring the urgent need for adaptive interventions.

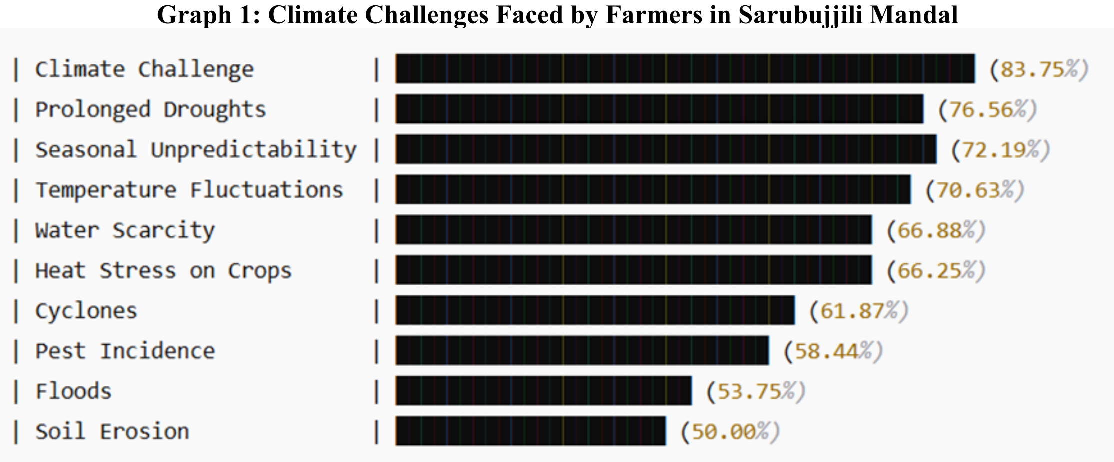
Table 2: Frequency of Climate-Related Challenges Reported by Farmers (*N = 320*)

Climate Challenge	Number of Farmers Reporting	Percentage (%)
Erratic Rainfall	268	83.75%
Prolonged Droughts	245	76.56%
Unexpected Floods	172	53.75%
Cyclones	198	61.87%
Soil Erosion	160	50.00%
Water Scarcity/Irrigation	214	66.88%
Temperature Fluctuations	226	70.63%
Heat Stress on Crops	212	66.25%
Increased Pest Incidence	187	58.44%
Seasonal Unpredictability	231	72.19%

Source: Field Survey

The findings reveal a stark prevalence of climate-induced challenges among the farmers in Sarubujjili Mandal. Erratic rainfall (83.75%) and prolonged droughts (76.56%) emerged as the most pressing issues, highlighting increased variability in monsoonal behavior. A significant proportion also reported seasonal unpredictability (72.19%) and temperature fluctuations (70.63%), suggesting that traditional farming calendars and cropping patterns are becoming increasingly unreliable.

Graph 1: Climate Challenges Faced by Farmers in Sarubujjili Mandal



Water scarcity (66.88%), heat stress on crops (66.25%), and cyclones (61.87%) were also frequently cited, indicating compounding effects on irrigation reliability and crop health. Increased pest incidence (58.44%) and soil erosion (50.00%) further demonstrate the cascading impact of climate stressors on crop productivity and land quality.

This data underscores the urgent need for context-specific adaptive strategies, particularly for small and marginal farmers, who are disproportionately affected due to limited access to irrigation, capital, and institutional support. The findings call for policy attention toward localized climate resilience planning, incorporating both traditional practices and scientific knowledge.

2. To Analyze the Adaptive Agricultural Strategies Practiced at the Community and Household Levels

The field data collected from Kondavalasa and Isakalapalem villages reveal a rich spectrum of adaptive agricultural strategies practiced by farming households in response to increasing climate variability. These adaptations, shaped by both environmental necessity and institutional influence, operate at both community and household levels.

Community-Level Adaptive Strategies

At the community level, collective actions and institutional interventions have significantly contributed to resilience-building. One of the most commonly observed practices is collective water harvesting, where small check dams, farm ponds, and percolation tanks have been constructed through both self-initiated community efforts and government schemes such as MGNREGS and NICRA. These structures have enhanced groundwater recharge, enabling irrigation during dry spells. Another prominent adaptation is the maintenance of local irrigation infrastructure, including desilting of canals, shared use of bore wells, and rotational water distribution systems. These efforts have promoted equitable water access among small and marginal farmers. Additionally, the introduction of crop insurance schemes, particularly under the Pradhan Mantri Fasal Bima Yojana (PMFBY), has provided a safety net against climate-induced crop losses, though issues with coverage and timely compensation remain challenges. Farmer Producer Organizations (FPOs) and cooperative societies have played a key role in information dissemination, bulk input procurement, and post-harvest marketing, enabling collective resilience against both climatic and market risks.

Household-Level Adaptive Strategies

At the household level, farmers have implemented a diverse range of tactical adjustments to enhance the climate resilience of their agricultural systems. Crop diversification stands out as a widely adopted strategy. Farmers have moved from mono-cropping to mixed cropping and intercropping systems, integrating cereals, legumes, and oilseeds to spread risk and maintain soil fertility. A notable trend is the shift toward drought-tolerant and short-duration crop varieties, particularly in paddy and pulses, sourced through agricultural extension services and KVK (Krishi Vigyan Kendra) initiatives. This has improved yield reliability under erratic rainfall conditions.

Adjustment of sowing and harvesting calendars to better align with unpredictable monsoon onset and retreat has become common practice. Some farmers now rely on real-time weather advisories provided via mobile-based services or through ATMA and NICRA coordination units to guide planting decisions. Soil and water conservation measures, such as mulching, contour bunding, and vermicomposting, have gained ground among progressive farmers, leading to improved moisture retention and organic matter in the soil. Additionally, integrated pest and nutrient management (IPNM) techniques are being applied to reduce input costs and chemical dependency while enhancing resilience. Livestock integration into farming systems has emerged as a riskbuffering strategy, particularly for landless and marginal farmers. Small ruminants and backyard poultry are raised to diversify income and provide nutrient security. Agroforestry, including the plantation of fruit trees and fodder crops on field boundaries, has also shown promise in improving microclimate regulation and providing supplemental income.

Synthesis and Interpretation

These adaptive strategies represent a hybrid approach, blending indigenous knowledge systems with scientific recommendations. While traditional timing and crop preferences continue to inform decisions, institutional support has helped introduce new practices and technologies. This suggests a strong adaptive learning capacity within the farming communities. However, the adoption of such practices is not uniform across all households. Factors such as landholding size, access to irrigation, education level, institutional linkage, and availability of credit influence the type and intensity of adaptation. Smallholders often adopt low-cost, labor-intensive strategies, while better-off farmers are more likely to invest in mechanized solutions or participate in insurance programs.

Table 3: Distribution of Adaptive Agricultural Strategies in Kondavalasa and Isakalapalem *(N = 320)*

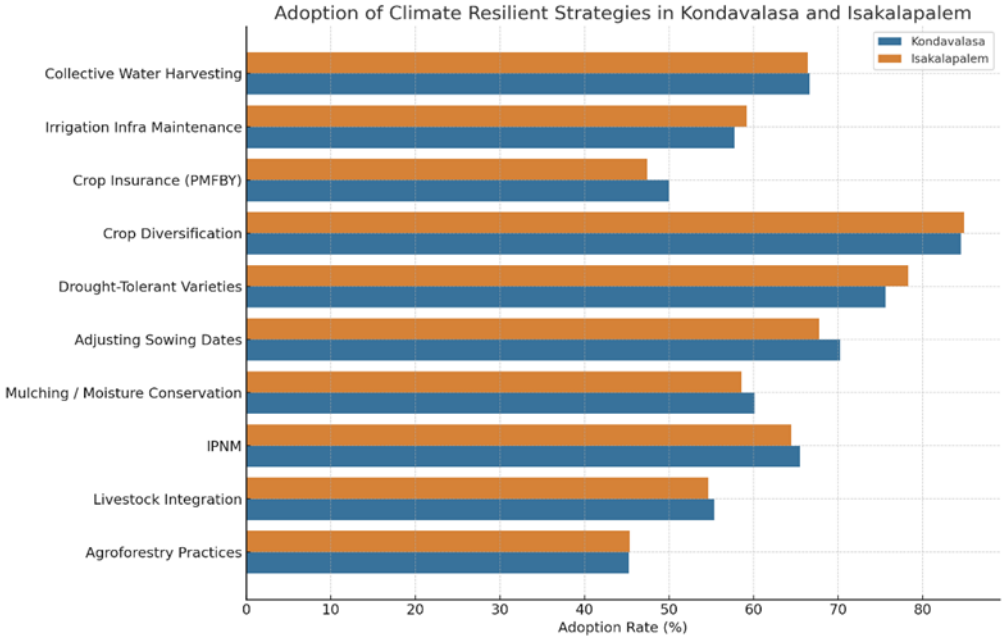
Adaptive Strategy	**Type**	**Kondavalasa *(n = 168)***	**%**	**Isakalapalem *(n = 152)***	**%**	**Total *(N = 320)***	**%**
Collective Water Harvesting	Community	112	66.67	101	66.45	213	66.56
Irrigation Infrastructure Maintenance	Community	97	57.74	90	59.21	187	58.44
Participation in Crop Insurance (PMFBY)	Community	84	50.00	72	47.37	156	48.75
Crop Diversification	Household	142	84.52	129	84.87	271	84.69
Use of Drought-Tolerant Varieties	Household	127	75.60	119	78.29	246	76.88
Adjusting Sowing Dates	Household	118	70.24	103	67.76	221	69.06
Mulching / Moisture Conservation	Household	101	60.12	89	58.55	190	59.38
Integrated Pest/Nutrient Management (IPNM)	Household	110	65.48	98	64.47	208	65.00
Livestock Integration	Household	93	55.36	83	54.61	176	55.00
Agroforestry Practices	Household	76	45.24	69	45.39	145	45.31

Source: Field Survey

Insights from the Data

- Crop diversification is the most widely adopted strategy, with more than 84% of households practicing it in both villages.
- Over 75% of farmers are adopting drought-resistant seeds, showing strong uptake of climate-smart inputs.
- Community-led initiatives, such as water harvesting and irrigation maintenance, have a strong presence in both villages, each with around 66% participation.
- Agroforestry and livestock integration are moderately adopted but show potential for expansion.
- Participation in PMFBY (crop insurance) is below 50%, indicating room for improving institutional linkage and farmer confidence.

Graph 2: Adoption of Climate Resilient Strategies in Kondavalasa & Isakalapalem



The comparative bar chart shows the adoption rates of various climate-resilient agricultural strategies in Kondavalasa and Isakalapalem. This visualization highlights similarities and variations in adaptation patterns between the two villages.

3. To Assess the Role of Local Knowledge, Institutions, and Government Schemes in Facilitating Climate Resilience

Climate resilience in agriculture is not only shaped by external interventions but also by the knowledge systems, institutional networks, and government support mechanisms available to rural communities. In both Kondavalasa and Isakalapalem villages, evidence reveals a synergistic role of local knowledge, institutions, and state-backed schemes in helping farmers navigate climatic challenges and sustain livelihoods.

1. Local Knowledge: The Foundation of Practical Resilience

Farmers in both villages possess a deep-rooted understanding of local climatic patterns, soil behavior, and ecological indicators. This indigenous knowledge plays a critical role in guiding decisions such as crop selection, sowing dates, water conservation practices, and pest management. For example:

- Farmers rely on traditional indicators like bird migration, wind patterns, and soil moisture feel to decide planting time, which becomes crucial when monsoon patterns are unpredictable.
- Mixed cropping and intercropping practices embedded in tradition are widely used to manage risk and increase yield stability.
- Seed selection and preservation techniques, passed down over generations, contribute to in situ conservation of climate-resilient landraces.

Despite the value of local knowledge, its effectiveness is often constrained by increasing climate variability and the need for scientific input. However, when combined with institutional support, its relevance and scalability improve.

2. Role of Institutions: Catalysts for Organized Resilience

A variety of institutions, both formal and informal, play a critical role in knowledge dissemination, resource coordination, and risk-sharing.

- Village Panchayats often coordinate community efforts like desilting tanks, repairing irrigation infrastructure, or facilitating access to state schemes.

- Self-help groups (SHGs), particularly among women, contribute to climate resilience through small savings, input pooling, and livelihood diversification activities like backyard poultry and handicrafts.
- Farmer Producer Organizations (FPOs) and cooperatives aid in aggregating produce, reducing input costs, and providing a platform for climate-resilient value chains.

Government-affiliated knowledge platforms such as the Krishi Vigyan Kendras (KVKs), Agricultural Technology Management Agency (ATMA), and extension departments serve as bridges between scientific research and the farming community. They promote modern adaptive strategies such as integrated nutrient management, drought-resilient seeds, and precision farming tools. Moreover, farmers reported that institutions like Primary Agricultural Cooperative Societies (PACS) help in facilitating access to seeds, fertilizers, and credit, especially during crisis years.

3. Role of Government Schemes: Enablers of Adaptation and Risk Mitigation

Multiple government programs have been instrumental in enhancing the climate resilience of agriculture in the region:

- National Innovations in Climate Resilient Agriculture (NICRA) has demonstrated climate-resilient interventions in nearby model villages. Though not directly implemented in the studied villages, its influence is felt through regional training, water harvesting demonstrations, and exposure visits.
- MGNREGS contributes to asset creation like farm ponds, bunding, and check dams, which support drought-proofing and enhance soil and water conservation.
- Pradhan Mantri Fasal Bima Yojana (PMFBY), while adopted by nearly half the farmers surveyed, suffers from mixed perceptions due to delays in compensation and lack of awareness of claim processes.
- Sub-Mission on Agricultural Extension (SMAE) and National Mission on Sustainable Agriculture (NMSA) promote agroforestry, integrated farming, and organic inputs through subsidies and technical training.
- e-NAM (National Agricultural Market) and digital soil health cards have also made inroads in improving decision-making, though digital access remains a barrier for older and less-educated farmers.

Synthesis and Insights

The intersection of local knowledge, institutional engagement, and structured government support forms the triad of climate resilience in rural Andhra Pradesh. The adaptive capacity of farmers is significantly higher where these three pillars reinforce each other. For instance:

- In Kondavalasa, higher participation in SHGs and Panchayat-led irrigation efforts correlate with better community-level adaptation outcomes.
- In Isakalapalem, farmers with access to KVK resources and PMFBY insurance showed greater willingness to invest in drought-resilient inputs.

However, gaps remain:

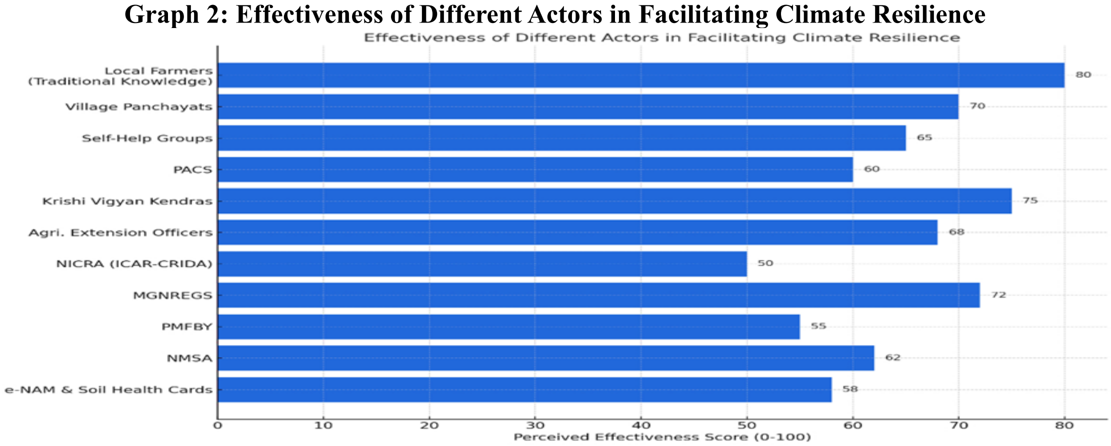
- Fragmented institutional coordination often leads to scheme duplication or poor uptake.
- Local knowledge systems are under-documented and not fully integrated into extension frameworks.
- Climate resilience-building remains reactive rather than proactive due to limited anticipatory planning at the grassroots level.

Table 4: Key Actors and Their Roles in Facilitating Climate Resilience

Actor/Agency	Level	Key Contributions	Challenges/Gaps
Local Farmers (Traditional Knowledge)	Household	- Seed saving & sharing - Rain-based crop planning - Intercropping & mulching	Limited against extreme events; underutilized by institutions
Village Panchayats	Community	- Collective irrigation repair - Mobilizing MGNREGA for water harvesting	Low technical capacity; reliance on external funding
Self-Help Groups (SHGs)	Community	- Alternative livelihoods - Small loans for inputs - Women's empowerment	Credit size is often small; training is needed for scaling activities
Primary Agricultural Cooperative Societies (PACS)	Community	- Input distribution - Credit access - Market linkage support	Bureaucratic delays, irregular availability of quality inputs
Krishi Vigyan Kendras (KVKs)	District/Sub-district	- Farmer training - Introduction of drought-resilient crops - Demonstration plots	Limited reach in remote areas; language/format barriers
Agricultural Extension Officers (Dept. of Agriculture)	Block level	- Advisory services - Support for scheme enrollment - Soil health awareness	High farmer-officer ratio; logistical constraints
NICRA (by ICAR-CRIDA)	National/District	- Model climate-resilient villages - Pilot adaptive practices	Not implemented in all areas; indirect influence in the study area
MGNREGS	National	- Creation of water bodies - Soil bunding & drought-proof assets	Delayed payments; poorly monitored asset maintenance
PMFBY (Crop Insurance)	National	- Risk mitigation through compensation for crop failure	Low awareness; claim process delays
National Mission on Sustainable Agriculture (NMSA)	National	- Agroforestry - Soil conservation subsidies - Organic farming promotion	Scheme access often limited to registered or larger farmers
e-NAM & Soil Health Card Schemes	National	- Access to wider markets - Soil-based nutrient recommendations	Digital literacy gaps; limited infrastructure

Source: Field Survey

Graph 2: Effectiveness of Different Actors in Facilitating Climate Resilience



The graphical presentation shows the perceived effectiveness of different actors in facilitating climate resilience. The horizontal bar chart makes it easy to compare contributions across local, institutional, and government levels.

4. To Evaluate the Effectiveness and Sustainability of Adaptive Agricultural Strategies in the Context of Changing Climate Patterns

Climate change has amplified the urgency to adopt adaptive agricultural strategies that are not only effective in the short term but also sustainable in the long run. In the case study villages of Kondavalasa and Isakalapalem, a range of strategies have been adopted by farmers in response to variable rainfall, rising temperatures, and shifting monsoon patterns. This section evaluates these strategies on two main dimensions: effectiveness (their ability to reduce vulnerability and stabilize yields) and sustainability (their long-term viability without causing ecological or economic harm).

1. Effectiveness of Adaptive Strategies

The effectiveness of a strategy is determined by its ability to meet the following goals:

- Stabilize production under erratic climatic conditions.
- Reduce vulnerability to droughts, pests, and crop failure.
- Enhance livelihood security through income diversification.

Table 5: Effective Strategies Observed

Strategy	Outcome Indicators	Remarks
Crop Diversification	Stable yields; risk spreading across multiple crops	High adoption rate; successful
Drought-Tolerant Varieties	Improved survival during dry spells	Performance varies by season
Mulching and Moisture Conservation	Better soil moisture retention, reduced irrigation need	Cost-effective and widely used
Intercropping & Mixed Cropping	Soil fertility, pest control, and resilience to single-crop failure	Traditional yet effective
Adjustment of Sowing Dates	Synchronization with monsoon variability	Needs accurate weather info
Agroforestry Practices	Shade for crops, soil conservation, and additional income	Long-term impact visible
Livestock Integration	Buffer income during crop failure	Depends on fodder availability

Source: Field Survey observation

2. Sustainability Assessment

Sustainability refers to the long-term continuation of these strategies without degrading resources or creating dependency. The following factors were used to assess sustainability:

- **Ecological Impact:** Does the strategy preserve or improve soil, water, and biodiversity?
- **Economic Viability:** Is the strategy affordable and profitable over time?
- **Social Acceptability:** Is the strategy culturally relevant and inclusive?

Sustainability Highlights:

- **Ecological Benefits:** Practices like intercropping, mulching, and agroforestry enhance biodiversity and reduce the use of chemical inputs.
- **Economic Viability:** Crop insurance (PMFBY) and government-subsidized inputs improve risk management, but delays in implementation reduce trust.
- **Social Dimensions:** SHGs and women-led activities have improved social inclusion and livelihood resilience.

However, sustainability challenges include:

- **Input dependency:** Some resilient practices promoted by institutions rely heavily on external seeds, fertilizers, or machinery (e.g., hybrid seeds), which may not be accessible to all.
- **Knowledge gaps:** Farmers need continuous training and support to maintain and adapt these practices, especially in the face of evolving climate risks.
- **Scheme fatigue:** When schemes are inconsistent or politically influenced, farmers lose interest or revert to unsustainable methods.

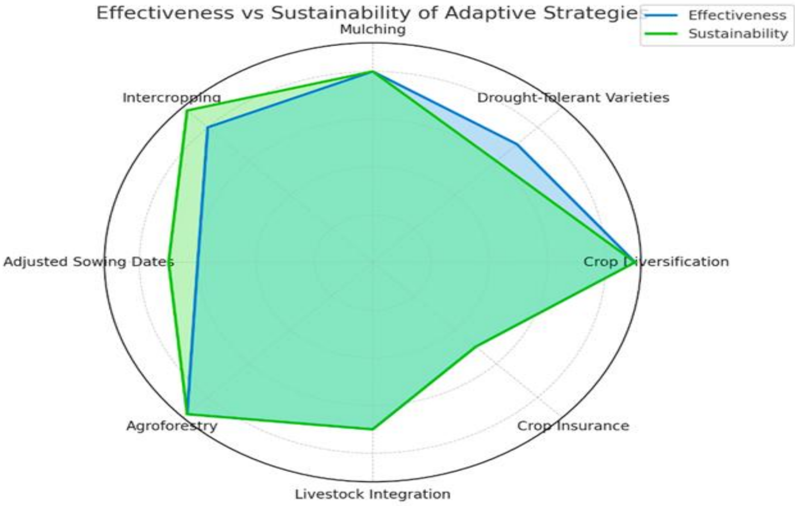
3. Climate Sensitivity and Strategy Robustness

Changing rainfall patterns and increasing extreme weather events are testing the robustness of these adaptive strategies. Some practices are more climate-sensitive than others:

Strategy	**Sensitivity to Climate Variability**	**Robustness Score *(out of 10)***
Crop Diversification	Low	9
Hybrid/Drought Varieties	Medium (depends on accuracy)	7
Mulching	Low	8
Crop Insurance	High (depends on policy design)	5
Adjusted Sowing Dates	Medium	6
Agroforestry	Low (very robust)	9
Livestock Integration	Medium (fodder sensitivity)	7

The most robust strategies tend to be nature-based and low-input, while externally dependent strategies (like insurance) may falter in implementation.

Graph 2: Effectiveness vs Sustainability of Adaptive Strategie



The radar chart compares the effectiveness and sustainability of various adaptive agricultural strategies. It visually highlights which practices are both high-performing and sustainable (e.g., agroforestry, crop diversification), and which may need improvement (e.g., crop insurance).

CONCLUSION

The findings of this study demonstrate that climate change is no longer a distant or abstract threat; it is a lived reality for farming communities in Sarubujjili Mandal. Based on in-depth fieldwork in Kondavalasa and Isakalapalem villages, it is evident that the agricultural sector is under significant stress due to increasing variability in rainfall, rising temperatures, and the unpredictability of extreme weather events. These changes are directly affecting crop yields, soil health, and water availability, critical factors that determine food security and rural livelihoods in this region.

Farmers have shown remarkable resilience by adopting a range of adaptive strategies rooted in both traditional knowledge and modern innovations. These include crop diversification, drought-tolerant varieties, mulching, adjusted sowing calendars, livestock integration, and agroforestry. At the community level, initiatives such as collective water harvesting, maintenance of irrigation systems, and crop insurance enrollment further strengthen the resilience framework. The study also finds that local institutions, such as Panchayati Raj Institutions (PRIs), self-help groups (SHGs), and farmer producer organizations (FPOs), play a critical role in enabling collective action, knowledge sharing, and access to government schemes. Government interventions, especially under programs like NICRA (ICAR-CRIDA), PMFBY, MGNREGS, and NMSA, have been instrumental in supporting climate-resilient farming practices, though implementation challenges remain.

However, while many of these practices are effective, their long-term sustainability is contingent upon continuous support, institutional coordination, and policy reinforcement. Challenges such as delayed subsidies, insufficient extension services, fragmented landholdings, limited access to climate-smart technologies, and lack of real-time weather information impede the widespread adoption and effectiveness of these strategies. The study highlights disparities in access to resources and decision-making power, especially for marginal farmers, women, and tribal households. These social dynamics must be taken into account to ensure that climate resilience is inclusive and equitable.

Policy Recommendations

To enhance the effectiveness and sustainability of adaptive agricultural strategies in Sarubujjili Mandal and other vulnerable agro-ecological zones, the following multi-level policy recommendations are proposed:

1. Strengthen Climate-Smart Extension Services

- o Develop village-level climate advisory cells linked to Krishi Vigyan Kendras (KVKs) and agromet centers.
- o Train local resource persons and progressive farmers as "climate resilience champions" to disseminate best practices.
- o Use mobile-based platforms and local FM radio for timely weather alerts and customized crop advisories.

2. Invest in Agroecological Infrastructure

- o Promote community-level water harvesting structures like farm ponds, percolation tanks, and check dams through the convergence of MGNREGS and agriculture department funds.
- o Encourage solar-powered irrigation systems and micro-irrigation techniques (drip/sprinklers) with higher subsidies for small and marginal farmers.
- o Revive and strengthen traditional irrigation systems (e.g., tanks and canals), ensuring equitable access.

3. Scale Up Climate-Resilient Cropping Systems

- o Promote locally suitable, drought/heat/flood-tolerant varieties through participatory varietal trials and seed banks.
- o Encourage intercropping, agroforestry, and crop-livestock integration models with market linkage support.
- o Provide input kits tailored for climate-resilient farming under state agriculture schemes.

4. Reform Risk Management and Insurance Mechanisms

- o Improve the transparency, timeliness, and outreach of PMFBY by digitizing enrolment and claim settlement systems.
- o Develop index-based insurance products for rainfed and dryland crops, piloted at microclimatic zones.
- o Provide disaster risk buffers and minimum support prices (MSPs) for climate-resilient crops like millets, pulses, and oilseeds.

5. Foster Inclusive and Participatory Governance

- o Ensure the active involvement of women, tribal communities, and youth in local adaptation planning.
- o Support formation and capacity building of climate-resilient SHGs and FPOs with special focus on vulnerable groups.
- o Facilitate community-led adaptation planning under district-level Climate Resilient Agriculture Action Plans (CRAAPs).

6. Integrate Research and Local Knowledge

- o Bridge the gap between scientific research institutions and farmers by encouraging field-level participatory research.

- Document and promote indigenous climate resilience practices in seed saving, water conservation, and pest control.
- Foster partnerships between academic institutions, NGOs, and line departments to co-create locally viable solutions.

7. Monitor, Evaluate, and Mainstream Climate Resilience

- Institutionalize village climate risk assessments using GIS tools and historical data to track vulnerability trends.
- Develop real-time dashboards at the mandal/district level to monitor adoption rates and impacts of adaptive practices.
- Integrate climate resilience metrics into agricultural planning, budgeting, and outcome reporting frameworks.

Final Reflections

This study reinforces that building climate resilience in agriculture is not a linear or purely technical process it requires a systems-based approach that integrates social, ecological, technological, and institutional dimensions. The experience of farmers in Sarubujjili Mandal shows that resilience is both an outcome and a process shaped by local agency, external support, and adaptive learning. As climate change intensifies, India's food security and rural prosperity will depend on how effectively local strategies are nurtured, scaled, and embedded within national frameworks. This requires political will, sustained investment, decentralized governance, and a commitment to equity and innovation. By placing farmers at the center of the resilience-building agenda and aligning policy frameworks with ground realities, we can transform vulnerability into opportunity and agriculture into a solution for climate change rather than a casualty.

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REFERENCES

1. Aggarwal, P. K., Kalra, N., Chander, S., & Pathak, H. (2006). Climate Resilient Agriculture in India. *National Academy of Agricultural Sciences (NAAS) Policy Paper No. 65*.
2. Singh, R. K., & Singh, S. (2019). Climate change and Indian agriculture: A systematic review of adaptation strategies. *Journal of Environmental Management*, 234, 383–394.
3. Indian Council of Agricultural Research (ICAR). (2011). National Innovations on Climate Resilient Agriculture (NICRA).
4. Mishra, V., Bhatia, U., & Tiwari, A. D. (2020). Bias-corrected climate projections from CMIP6 for South Asia. *arXiv preprint arXiv:2006.12976*.
5. Chetri, P., Sharma, U., & Ilavarasan, P. V. (2021). Role of Information and ICTs as Determinants of Farmer's Adaptive Capacity to Climate Risk: An Empirical Study From Haryana, India. *arXiv preprint arXiv:2108.09766*.
6. Grigorieva, E., Livenets, A., & Stelmakh, E. (2023). Adaptation of Agriculture to Climate Change: A Scoping Review. Climate, 11(10), 202. https://doi.org/10.3390/cli11100202 https://doi.org/10.3390/cli11100202
7. Viswanathan, P. K., Kavya, K., & Bahinipati, C. S. (2020). Global Patterns of Climate-resilient Agriculture: A Review of Studies and Imperatives for Empirical Research in India. Review of Development and Change, 25(2), 169-192. https://doi.org/10.1177/0972266120966211

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