Study on
Impact of Climate Change on Rice Cultivation in Kerala and Development of Mitigation and Adaptation Strategies

FINAL REPORT

NABARD

Supported by:
National Bank for Agriculture and Rural Development (NABARD)

Under the:
Climate Change Fund -Interest Differential (CCF-ID)
Ref. No. NB (Kerala)/DCAS/CCF-ID/34906/DCAS-3/2024-25

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August, 2025

Final Report

STUDY ON IMPACT OF CLIMATE CHANGE ON RICE CULTIVATION IN KERALA AND DEVELOPMENT OF MITIGATION AND ADAPTATION STRATEGIES

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Implemented by :
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All figures are correct as on 1st August 2025 unless otherwise stated.

The findings and conclusions presented regarding the challenges and solutions in paddy farming are generalized insights based on the collective responses of community members who participated in the survey. This information is intended solely to support efforts to understand and improve community conditions. It should not be interpreted as representing the views or circumstances of any specific individual or group. Field testing of protocols and carbon studies has been conducted in collaboration with the respective divisions of TIES.

Preface

Climate change has emerged as one of the most significant threats to agriculture, particularly in regions like Kerala where paddy cultivation is deeply intertwined with local ecosystems, livelihoods, and food security. Erratic rainfall, temperature extremes, increasing pest and disease outbreaks, and changing hydrological patterns are increasingly jeopardizing the sustainability of rice farming in the state. This project was conceptualized against this backdrop, with the objective of developing actionable strategies to mitigate and adapt to the adverse effects of climate change on rice cultivation. To ensure regional relevance and practical applicability, the study was conducted in four key rice-growing districts of Kerala: Palakkad, Alappuzha, Kottayam, and Thrissur.

Through a participatory and evidence-based approach, a Climate Resilient Protocol was developed by integrating traditional wisdom and successful practices of progressive farmers with expert inputs. It was subsequently implemented in collaboration with a Padasekhara Samithi in each of the selected districts. The field implementation yielded promising results across multiple dimensions—enhanced yield, reduced cultivation cost, lowered agrochemical toxicity, improved adoption of modern technologies, greater resilience to climatic aberrations, and increased carbon sequestration potential. These outcomes demonstrate that the developed protocol has significant potential to sustain and strengthen rice cultivation across diverse agro-ecological zones in Kerala.

This report presents the detailed findings of the study and the outcomes of the implemented strategies. It is expected that the insights and recommendations presented here will contribute meaningfully to policy planning, farmer support systems, and the broader discourse on climate-resilient agriculture.

Dr. Punnen Kurian
Project Head

Acknowledgement

We gratefully acknowledge the support of the National Bank for Agriculture and Rural Development (NABARD) for sanctioning and funding this project. We extend our sincere thanks to Mr. Reji Varghese, Assistant General Manager – District Development, Kottayam, NABARD; Mr. Vasudev N, Assistant Manager, Department of Climate Action and Sustainability, NABARD, Kerala; and all other officials of NABARD for their timely guidance, and continued support throughout the implementation of the project. We also thank Mr. Raju Philip, Lead District Manager, Lead Bank, Kottayam, for his support during the project period.

We are deeply indebted to the farmers of the Padasekhara Samithis who collaborated with us in implementing the Climate Resilient Protocol. Their commitment and cooperation were instrumental in translating the protocol into practice. We sincerely thank the Rajaramapuram Padasekhara Samithi in Alappuzha, Koorodmannu Padasekhara Samithi in Palakkad, Kelakari Vattakayal and Kapponappuram Padasekhara Samithis in Kottayam, and the Vennippadam Vadakke Bhagam Nellulpadaka Karshaka Sangham in Thrissur for their wholehearted participation.

We also express our sincere appreciation to the farmers from the conventional Padasekhara Samithis who supported the study by sharing information on their cultivation practices and permitting field sample collection. These include the 24,000 Kayal Nellulpadaka Samithi in Alappuzha, Vallakkunnam Padasekhara Samithi in Palakkad, Poovath Thollayiram Kizhakku Padasekhara Nellulpadaka Samithi and Akathekari Padasekhara Samithi in Kottayam, and the Vennippadam Ponmani Karshaka Sangham in Thrissur.

We extend our thanks to all the farmers across the selected districts who cooperated with us during the initial surveys, enabling the collection of ground-level information with clarity and depth. We also acknowledge the support of the Agricultural Officers and Agricultural Assistants in each district, who provided essential field-level information and facilitated access to local farmers and records. Their cooperation significantly contributed to the successful execution of the study.

We are especially thankful to Dr. G Jayalekshmi, Head of Krishi Vigyan Kendra (KVK), Kottayam, for her expert guidance and field-level engagement. We also acknowledge Ms. Chris Joseph, Assistant Professor, KVK Kottayam, for her guidance and technical support during the course of the project. Our gratitude further extends to Dr. Vinod Mathew, Subject Matter Specialist (Agronomy) at ICAR-KVK, Pathanamthitta, for his contributions in designing the protocol and providing valuable insights throughout the study. We gratefully acknowledge Dr. Abin Varghese, GIS Analyst at Mahatma Gandhi University, for his support in spatial analysis and mapping.

Finally, we extend our heartfelt gratitude to the entire staff of the Tropical Institute of Ecological Sciences (TIES) for their unwavering support across all stages of the project; from planning and coordination to field execution and documentation.

Project Team

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1.1. INTRODUCTION

Rice *(Oryza sativa L.)* is one of the most significant staple crops globally, serving as the primary food source for more than half of the world's population. It is cultivated extensively across Asia, Africa, and parts of Latin America, playing a pivotal role in ensuring food security, sustaining livelihoods, and supporting rural economies. According to the Food and Agriculture Organization (FAO), the global rice production in 2023 was approximately 520 million metric tonnes (milled equivalent), with Asia accounting for nearly 90% of the world's rice production and consumption. China, India, Indonesia, Bangladesh, and Vietnam remain the top rice-producing countries globally, with China and India together contributing more than half of the total global output (FAO, 2024).

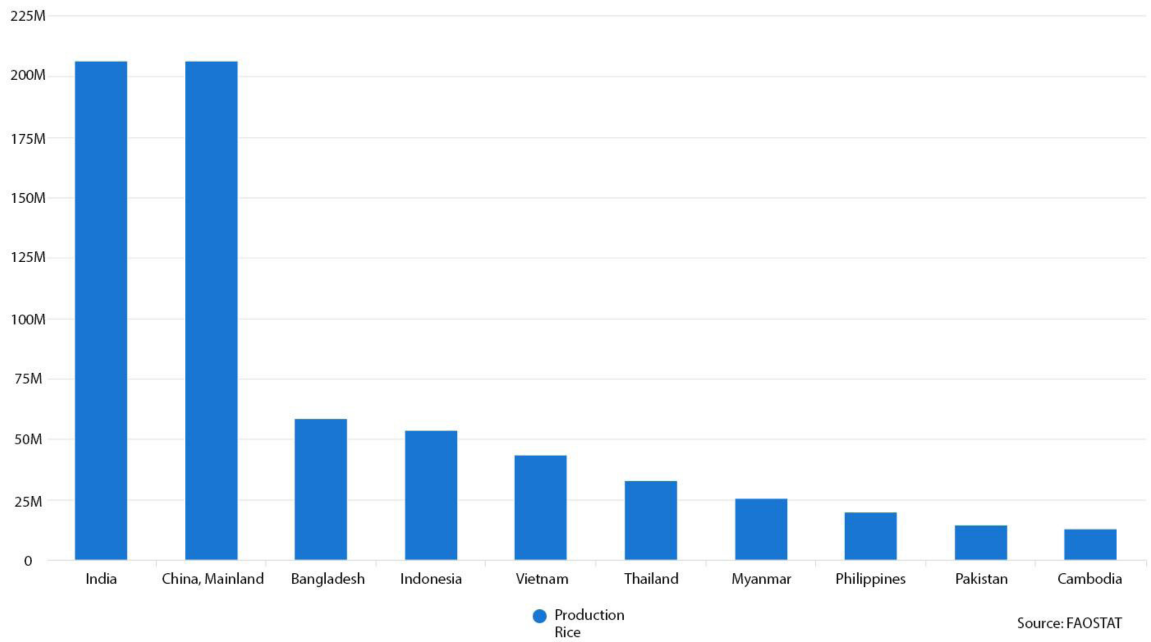

Fig 1.1. Top 10 rice producing countries in the world (2023)

India holds a prominent position in global rice cultivation, being both the largest exporter and the second-largest producer after China. As per data from the Ministry of Agriculture and Farmers Welfare (Government of India), India produced around 135.8 million tonnes of rice during the 2023-24 agricultural year, covering a total area of approximately 45 million hectares under paddy cultivation. Rice is not just a dietary staple in India but also a crucial component of the country's agrarian economy, contributing significantly to rural employment, food security, and export revenues. Major rice-growing states in India include West Bengal, Uttar Pradesh, Punjab, Bihar, Chhattisgarh, Andhra Pradesh, Odisha, and Tamil Nadu (Government of India, 2024).

Kerala holds a distinctive place in the rice cultivation landscape of India, despite not being among the largest producers in the country. Paddy farming is deeply intertwined with the state's history, culture, and food habits. Traditionally, rice has been the staple food of Kerala, and paddy fields have played a central role in shaping the rural economy, landscape, and agrarian lifestyle of the region. The state's unique agro-ecological zones, including the Kuttanad wetlands—often referred to as the "Rice Bowl of Kerala"—the Palakkad plains, and the Kole lands of Thrissur, have long been renowned for their paddy production.

Rice cultivation continues to hold significant agronomic and cultural value in Kerala, despite a gradual reduction in cultivated area over the years. According to the Compendium of Agricultural Statistics: Kerala 2023, the total rice production in the state for the latest reporting year was approximately 641,575 tonnes, harvested from an area of about 263,529 hectares. The average yield achieved during this period was 2,435 kilograms per hectare, which, although slightly below the national average, reflects the productivity of Kerala's wetland rice ecosystems (Department of Agriculture, Government of Kerala, 2023).

1.1.1. Challenges Faced by Paddy Cultivation

Paddy cultivation, despite its central role in global and regional food security, faces multiple challenges that threaten its sustainability and profitability. One of the foremost issues is climate variability, including erratic rainfall, prolonged dry spells, unseasonal floods, and rising temperatures. These climatic fluctuations adversely affect sowing windows, crop growth stages, and overall yield potential. Studies have shown that rice is particularly sensitive to temperature increases, especially during the flowering stages, which can lead to significant yield reductions (IPCC, 2021).

Another major concern is water scarcity. Rice is traditionally a water-intensive crop, requiring substantial irrigation for puddling and field maintenance. However, declining groundwater levels, increasing competition for water resources, and changing rainfall patterns have made consistent water availability a growing challenge, especially in regions that lack efficient irrigation infrastructure (Bouman et al. 2007).

Soil degradation is also a pressing issue, resulting from the long-term overuse of chemical fertilizers, continuous monocropping, and improper land management practices. These factors have led to declining soil fertility, reduced organic matter content, and imbalanced nutrient cycles. According to the NITI Aayog report on Natural Farming (2021), such practices have contributed to soil degradation and have increased the cost of cultivation over time, thereby impacting the long-term sustainability of rice farming (NITI Aayog, 2021).

Another significant challenge is the shortage of agricultural labor, particularly in rice cultivation, which is traditionally labor-intensive. The migration of rural workers to urban areas and an aging farming population have led to a decline in the availability of farm labor. This has made critical operations such as transplanting, harvesting, and post-harvest processing more difficult and expensive. The NITI Aayog's Working Group Report (2021) notes that labor shortages are becoming a structural issue in Indian agriculture, forcing farmers either to mechanize or reduce the area under cultivation. However, in states like Kerala, where landholdings are small and fragmented, full mechanization remains challenging, intensifying the impact of labor scarcity (NITI Aayog, 2021).

Additionally, low profitability and market uncertainties discourage farmers from continuing paddy cultivation. Fluctuating paddy prices, high input costs, and inadequate procurement support often result in poor returns for farmers, making rice cultivation economically challenging, especially for smallholder and marginal farmers (India Today, 2023).

1.1.2. Challenges Faced by Paddy Cultivation in Kerala

One of the core issues in Kerala is the progressive shrinkage of rice-growing areas, especially in ecologically sensitive regions like Kuttanad, Kole lands, and Palakkad. This is largely due to conversion of paddy fields for non-agricultural purposes such as housing, infrastructure, and aquaculture. The Department of Economics and Statistics, Kerala (2024) highlights this long-term trend, noting a reduction in paddy land from 8.8 lakh hectares in the 1970s to just around 1.96 lakh hectares in 2023–24 (DES Kerala, 2024).

Additionally, Kerala faces unique ecological and climatic risks that directly affect rice production. The Kerala State Action Plan on Climate Change (SAPCC 2023–2030) specifically mentions that the state's rice cultivation is highly vulnerable to unseasonal rainfall, localized flooding, and saline water intrusion, especially in low-lying regions like Kuttanad. These factors disrupt planting schedules, damage standing crops, and reduce yields significantly (Kerala SAPCC, 2023).

Another Kerala-specific challenge is the lack of mechanization due to small and scattered landholdings. While mechanization is expanding in other parts of India, Kerala's field patterns, coupled with waterlogged conditions in many paddy zones, make large-scale mechanized farming difficult. The NITI Aayog Working Group Report (2021) notes that states like Kerala are structurally constrained from adopting large machinery due to plot fragmentation and ecological limitations (NITI Aayog, 2021).

In Kerala, despite government efforts to support paddy farmers through a procurement system with a Minimum Support Price and State Incentive Bonus, the system remains underdeveloped compared to other states due to several persistent challenges. Key issues include significant delays in payments to farmers, often exceeding twelve weeks, caused by the state's reliance on a loan-based system (Paddy Receipt Slips - PRS) through banks, which creates financial instability for farmers. Other constraints involve difficulties in meeting quality standards for paddy, inefficient loading and unloading processes, and delays in timely procurement due to asynchronous sowing schedules. Furthermore, the lack of sufficient storage and warehousing facilities exacerbates post-harvest losses, while restrictions on procurement quantities to prevent malpractices can also negatively impact farmers with higher yields.

A recent study by Siju et al. (2024) highlights the persistent challenges in Kerala's paddy procurement system from the farmers' perspective. The authors point out that despite government interventions, farmers face multiple constraints such as delayed payments, limited procurement centres, procurement quotas, and complex administrative procedures. These issues often force farmers to sell their produce to private traders at lower prices, leading to economic losses. The study emphasizes that unless procurement becomes more accessible, transparent, and efficient, farmers will continue to shift away from paddy cultivation, undermining the state's food security goals. Improving procurement infrastructure and ensuring timely payments are critical to sustaining Kerala's rice sector).

1.1.3. Climate Change and Weather Pattern Disruption

Climate change refers to long-term alterations in global or regional climate patterns, primarily driven by human activities such as the burning of fossil fuels, deforestation, and unsustainable land-use practices. The Intergovernmental Panel on Climate Change (IPCC) defines climate change as both global warming and its associated consequences, including rising temperatures, altered precipitation patterns, and the increased frequency of extreme weather events (IPCC, 2023). One of the most critical manifestations of climate change is the disruption of weather patterns, resulting in irregular monsoons, prolonged droughts, unseasonal rainfall, intensified cyclonic activity, and shifts in temperature regimes. These changes directly interfere with the predictability of seasonal cycles, upon which natural ecosystems and agricultural practices heavily depend.

Globally, the evidence of climate change is unequivocal. According to the IPCC Sixth Assessment Report (2023), the average global surface temperature has increased by approximately 1.1°C compared to pre-industrial levels, leading to a cascade of environmental changes. Glacier retreat, sea ice loss, and rising sea levels are becoming increasingly common across various parts of the world. The global mean sea level rose by 20 cm between 1901 and 2018, and projections indicate further increases by the end of the 21st century (IPCC, 2023). The concentration of atmospheric carbon dioxide has surpassed 419 parts per million, the highest level in recorded history (NOAA, 2024). These global changes are resulting in a higher incidence of climate extremes such as heatwaves, flash floods, hurricanes, and wildfires. The World Meteorological Organization (WMO) has documented a fivefold increase in weather-related disasters over the past 50 years (WMO, 2023). Climate change is not uniform in its impacts; it disproportionately affects developing and tropical regions, where communities often lack the resources and infrastructure needed for effective adaptation.

The consequences of climate change are extensive and multifaceted. Rising temperatures are leading to increased heat stress in both human and natural systems, while the intensification of weather extremes disrupts ecosystems, damages infrastructure, and displaces populations (UNEP, 2023). Alterations in the hydrological cycle are reducing the predictability of water availability, with severe implications for agriculture and drinking water supplies. Biodiversity loss is accelerating, as species face habitat changes and shifting climatic zones. Additionally, climate change is exacerbating public health risks through the spread of vector-borne diseases, heat-related illnesses, and food insecurity. The economic costs associated with these impacts are substantial, with climate-related disasters causing trillions of dollars in damages globally over the past two decades (UNDRR, 2023).

Agriculture is particularly sensitive to climate variability and change, making it one of the sectors most vulnerable to these disruptions. The Food and Agriculture Organization (FAO) highlights that climate change affects agricultural productivity through shifts in temperature, altered rainfall patterns, and increased frequency of pests and diseases (FAO, 2023). Changes in the onset and duration of cropping seasons complicate farm management decisions, while water scarcity driven by higher evapotranspiration rates places additional stress on irrigation resources. Furthermore, sea-level rise and saline intrusion, especially in coastal agricultural systems, reduce soil fertility and crop yields. In tropical regions like Kerala, where rice cultivation is intimately tied to monsoon behavior and wetland ecosystems, these climatic shifts pose serious challenges. Erratic rainfall, saline water intrusion in the Kuttanad region, and unpredictable temperature variations directly impact rice production. Smallholder farmers, who constitute the majority of the agricultural workforce in Kerala, are particularly at risk due to limited adaptive capacity and resource constraints.

Given the escalating risks posed by climate change, the development of climate-resilient agricultural strategies is no longer optional but essential. The need for region-specific adaptation protocols, improved resource management, and climate-smart agricultural practices is critical to ensuring food security, sustaining rural livelihoods, and building long-term ecological resilience.

1.1.4. Climate Change and Paddy Cultivation: A Global Perspective

Paddy cultivation is one of the most climate-sensitive agricultural sectors globally, particularly in Asia, where over 90% of the world's rice is produced and consumed. Climate change is now posing serious threats to rice production through a combination of rising temperatures, irregular rainfall patterns, increased frequency of extreme weather events, and environmental degradation. According to the IPCC Sixth Assessment Report (2022), global rice yields are projected to decline by approximately 3.2% for every 1°C rise in temperature, with severe impacts expected in tropical and subtropical regions where rice is the primary staple. Heat stress during sensitive stages such as flowering and grain filling reduces spikelet fertility, leading to significant yield losses. In countries like India, Bangladesh, Vietnam, Indonesia, and the Philippines, farmers are already facing the consequences of prolonged high-temperature exposure and altered monsoon patterns. The traditional rice-growing calendars in these regions are becoming increasingly unreliable, disrupting both planting and harvesting cycles.

Climate change is also intensifying water-related challenges in rice production. Rice is a water-intensive crop, typically grown in continuously flooded fields, but rising temperatures have increased evapotranspiration rates, intensifying water demand. Simultaneously, shifting rainfall patterns are leading to both drought and flood risks in rice-growing areas. For example, parts of Southeast Asia are experiencing longer dry spells, while others face excessive rainfall resulting in waterlogging and crop damage. This dual threat of droughts and floods not only reduces yields but also affects soil health and increases the risk of crop failures.

In coastal rice-producing regions, sea-level rise and saltwater intrusion are becoming critical problems. Low-lying areas such as the Mekong Delta in Vietnam and the Sundarbans in Bangladesh are facing increasing soil salinity, which significantly affects rice productivity since traditional rice varieties are sensitive to saline conditions. Farmers in these areas are being forced to abandon rice cultivation or shift to less profitable or ecologically risky alternatives, leading to socioeconomic instability.

Moreover, paddy cultivation itself is a major contributor to climate change due to methane (CH_4) emissions from flooded fields. The FAO (2023) estimates that rice production systems account for approximately 10% of global agricultural methane emissions, primarily through anaerobic decomposition of organic matter in continuously flooded paddies. Methane is a potent greenhouse gas, and its emissions from rice fields exacerbate global warming, creating a feedback loop that further threatens agricultural systems.

Fig 1.2. Delayed procurement after harvest

Fig 1.3. Waterlogged field caused by untimely rainfall during harvest

Fig 1.4. Weed infestation

Fig 1.5. Saline intrusion

1.1.5. Weather change pattern in Kerala

Kerala's climate is heavily influenced by the Southwest Monsoon, which historically accounts for nearly 68–70% of the state's annual rainfall and is vital for paddy cultivation. Traditionally, the monsoon season in Kerala begins around June 1st, providing the primary source of water for wetland rice fields, especially in regions like Kuttanad, Palakkad, and the Kole lands. However, recent decades have witnessed significant changes in monsoon patterns, largely driven by climate change. A long-term analysis of Kerala's rainfall data by Aype et al. (2005) reveals a 12% decline in monsoon rainfall over a period of 96 years, along with increased variability in rainfall distribution.

In recent years, Kerala has experienced a combination of delayed monsoon onset, erratic rainfall, and extreme weather events. For example, in 2018, Kerala experienced one of the worst flood disasters in nearly a century. The southwest monsoon, which commenced on May 29th, initially appeared normal; however, by August, the state was overwhelmed by unprecedented rainfall. Between 1st and 30th August 2018, Kerala received 96% excess rainfall, with some districts recording rainfall levels comparable to the catastrophic 1924 floods. The most intense spell occurred between 8th and 17th August 2018, during which Kerala experienced a cumulative rainfall of 414 mm, causing massive runoff, landslides, and river overflows (KSDMA, 2018). From August 8th to 22nd, the state faced widespread flooding across all 14 districts. The National Remote Sensing Centre (NRSC) reported that approximately 65,188 hectares of land were inundated, including the low-lying paddy fields of Kuttanad, which remained submerged for weeks. The event resulted in 339 human fatalities and massive destruction of agricultural lands, infrastructure, and livelihoods. The Kerala floods of 2018 are now widely recognized as an extreme climate event, attributed in part to changing monsoon dynamics and increased weather variability linked to global climate change.

Changing weather patterns linked to climate change have also intensified weed infestation in paddy fields, posing a growing challenge to both climate-resilient and conventional farming systems. Increased rainfall variability, unseasonal showers, and rising temperatures have altered weed emergence patterns and extended their growth periods, reducing crop competitiveness and increasing dependency on herbicides.

Table 1.1 Common weeds in Kerala paddy fields

Category	Scientific Name	Common Name	Local Name (Malayalam)
Grasses	Oryza rufipogon	Wild rice	Varinellu
	Echinochloa crus-galli	Barnyard grass	Kavada
	Echinochloa colona	Jungle rice	Kavada
	Echinochloa stagnina	Burgu grass	Kavada
	Sacciolepis interrupta	Interrupted cutgrass	Polla
	Isachne miliacea	Miliacea grass	Chovverippullu, Naringa
Sedges	Cyperus iria	Rice flat sedge	Manjakora, Chengoal
	Cyperus difformis	Smallflower umbrella sedge	Thalekkattan
	Fimbristylis miliacea	Grasslike fimbry	Mungai
Broadleaved Weeds	Monochoria vaginalis	Pickerel weed	Neelolppalam
	Ludwigia perennis	Perennial water primrose	Neer-Grampu
	Limnocharis flava	Yellow velvetleaf	Nagappola
	Ammania baccifera	Toothcup	Nellicheera
Ferns	Salvinia molesta	Giant salvinia	African Payal
	Marsilea quadrifolia	Four-leaf water clover	Naalilakodian
	Azolla pinnata	Water fern / Mosquito fern	Azola
Algae	Chara spp.	Stonewort	Chandi
	Spirogyra spp.	Filamentous green algae	Payal


Fig 1.6. Weed infestation

Studies project that climate change will reduce rice yields in India by 3–5% under medium emission scenarios and up to 10% under high emission scenarios (Palanisami et al. 2017).These unpredictable monsoon behaviors have serious implications for paddy cultivation in Kerala. Farmers face increasing difficulty in timing field preparation, transplantation, and harvesting. Early or late rains can damage seedlings, while prolonged dry spells require supplemental irrigation that is often unavailable or costly. When intense short-duration rainfall occurs, it leads to flash floods and waterlogging, destroying standing paddy crops and causing substantial economic losses. According to the Kerala State Action Plan on Climate Change (2023–2030), such rainfall variability, combined with rising temperatures, has already started to alter the agro-climatic conditions in the state, making rice farming more vulnerable than ever before. The shift from predictable monsoon patterns to a regime of weather extremes and uncertainty is forcing Kerala's paddy farmers to adapt quickly or face livelihood risks.

1.2. PROJECT BACKGROUND

The project titled "Study on the Impact of Climate Change on Rice Cultivation in Kerala and Development of Mitigation and Adaptation Strategies" addresses a critical issue confronting the state's agricultural sector. Despite the state government's extensive efforts, Kerala lost about 6,00,000 hectares of paddy fields between 1980 and 2020 due to a variety of reasons including climate change. The production during these years reduced by 50% and this decline in paddy produce has caused food insecurity in Kerala. The environment of the rice-growing agricultural wetland offers a vast array of goods and services both directly and indirectly. There are a multitude of socio-economic and ecological effects of converting paddy fields. Climate change directly affects precipitation and temperature, leading to water deficits, floods, changes in soil moisture status, and increased pest and disease incidence. Studies conclude that in India, climate change will reduce overall rice yield by 3 to 5% under a medium emission scenario and 3.5% to 10% under a high emission scenario (Palanisami et al., 2017). The present project is an attempt to address the drastic decline in paddy cultivation and production year by year, find out its reasons, document climate resilient practices of successful farmers, develop a sustainable farming protocol incorporating inputs from all stakeholders, and provide skill training to the larger paddy farming community and thus promote sustainable livelihood.

The proposal aligns with the Kerala State Action Plan on Climate Change (SAPCC), which emphasizes climate-proofing agriculture, improving value chain resilience, and strengthening support systems like procurement, storage, credit, and insurance. It also supports the goals of the National Action Plan on Climate Change (NAPCC) by focusing on adaptation strategies to enhance ecological sustainability and reduce vulnerability. Furthermore, it addresses India's Updated Nationally Determined Contributions (NDCs) under the Paris Agreement (2021–2030), which call for increased investment in climate adaptation, particularly in agriculture and water management sectors.

A preliminary climate and vulnerability analysis indicates that the social and livelihood vulnerabilities in Kerala, especially the reluctance of farmers to adopt new practices, are key challenges (Sathyan et al. 2016). This project will undertake a detailed assessment of the climate risks, adaptive capacity, and socio-economic vulnerabilities in the study areas to develop location-specific adaptation strategies.

1.3. OBJECTIVES

- To rank and prioritize the challenges faced by rice farming in Kerala (e.g., labor shortage, weather changes like floods, drought, untimely rain; climate change impacts, climate and vulnerability analysis etc.).
- To study the profile of the public and scientific/ technological interventions for improving or sustaining rice farming in the state (subsidy systems, other government supports, including insurance, involvement of other agencies, research, and scientific support from respective institutions, etc.).
- To document the best mitigation or adaptation practices developed by successful rice farmers and to form a climate-friendly protocol for rice farming in Kerala (changing the date of sowing, drought-resistant varieties, water-friendly irrigation practices,etc.).
- Training for knowledge transfer and capacity building of paddy farmers, for adoption of climate resilient farming practices, technologies for improving water wise efficiency, use of early warning systems etc.

1.4. CONCLUSION

Climate change, along with socio-economic and institutional factors, has created a complex set of challenges for rice cultivation in Kerala. The decline in paddy production and the shrinking area under cultivation are not isolated issues but are interconnected with changing weather patterns, labor shortages, market risks, and ecological degradation. The increasing frequency of erratic monsoon behavior—characterized by delayed onset, intense rainfall over short periods, and extended dry spells—has disrupted traditional farming calendars and made paddy cultivation more unpredictable. Simultaneously, water scarcity, soil degradation, pest outbreaks, and procurement-related inefficiencies further reduce the profitability and attractiveness of rice farming, particularly for smallholder and marginal farmers. Despite the introduction of support mechanisms like subsidies and minimum support price procurement, systemic hurdles such as payment delays, storage constraints, and fragmented landholdings continue to deter farmers from maintaining or expanding their paddy cultivation.

In summary, rice cultivation in Kerala is facing unprecedented challenges due to a combination of climate change, socio-economic shifts, and systemic constraints in the agricultural sector. The reduction in paddy area, declining yields, and increased vulnerability of rice farming are direct outcomes of erratic monsoon patterns, rising temperatures, labor shortages, market uncertainties, and institutional gaps. Recognizing these threats, the current project proposes a comprehensive approach to mitigate and adapt to the impacts of climate change on rice farming in the state. By identifying region-specific challenges, documenting successful farmer-led adaptations, and integrating scientific and policy-driven interventions, the initiative aims to develop a climate-resilient rice farming protocol for Kerala. The project will not only focus on technological solutions but also emphasize farmer capacity building, knowledge transfer, and community participation to ensure long-term sustainability. This integrated strategy is expected to enhance the resilience of the rice farming sector, protect rural livelihoods, and contribute to Kerala's broader climate adaptation goals.

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CHAPTER 2
Public Policy and Technological Interventions Supporting Sustainable Rice Farming in Kerala

2.1. INTRODUCTION

Paddy cultivation holds a central position in Kerala's agricultural economy, cultural identity, and food security framework. In recent years, the sector has faced escalating challenges due to climate variability, shrinking profitability, degradation of natural resources, and changing socio-economic dynamics. To address these concerns and transition towards a more sustainable and resilient rice production system, both the Government of India and the Government of Kerala have initiated a range of targeted schemes and interventions.

This review presents a comprehensive analysis of government schemes implemented during the financial year 2024–25 that directly or indirectly support sustainable rice development in Kerala. The schemes span across multiple dimensions of sustainability—ecological, economic, technological, and institutional—and are designed to promote climate-resilient farming, improve soil health, enhance input efficiency, strengthen post-harvest value chains, and empower farmer collectives.

The review encompasses both centrally sponsored and state-funded programmes, highlighting their budgetary allocations, operational mechanisms, and specific sub-components relevant to paddy cultivation. By aligning traditional practices with scientific innovations and policy incentives, these schemes collectively aim to safeguard the future of rice farming in the state while ensuring environmental stewardship and livelihood security for farming communities.

2.1.1 Objectives

- To document and review state and central government schemes supporting sustainable and climate-resilient rice farming in Kerala during 2024–25.
- To analyze policy interventions that address the challenges of climate variability, resource degradation, and declining profitability in paddy cultivation.
- To identify scheme components that promote eco-friendly inputs, soil health management, farm mechanization, and post-harvest value addition in the rice sector.
- To incorporate findings from recent scientific studies and projects relevant to climate-resilient paddy farming in Kerala.

2.2 METHODOLOGY

The review was conducted through systematic secondary data collection from official government sources, including budget documents, scheme guidelines, and departmental reports for the financial year 2024–25. Both state-sponsored and centrally sponsored schemes were identified and categorized based on their direct or indirect relevance to sustainable rice development in Kerala.

A thematic framework was adopted to classify interventions into key focus areas such as climate resilience, soil health management, eco-friendly input use, mechanization support, post-harvest value chain development, and institutional strengthening. Budget allocations, implementation strategies, and operational mechanisms were critically examined to assess the scope and impact of each scheme.

In addition to policy documents, the review integrated field-level insights from recent research projects, academic studies, and climate-resilient paddy farming models currently implemented in Kerala. This helped to contextualize the policy interventions with real-world agricultural practices and emerging challenges faced by the rice farming community. The combined approach of document analysis and case-based review ensures a comprehensive understanding of both the policy landscape and ground-level realities in promoting sustainable rice cultivation in the state.

2.3. STATE GOVERNMENT SCHEMES SUPPORTING SUSTAINABLE RICE DEVELOPMENT IN KERALA

2.3.1. Rice Development Scheme

Head of Account: 2401-00-102-90
Budget Allocation (2024–25): ₹9360.00 lakh

The Rice Development Scheme is the flagship initiative of the Government of Kerala aimed at enhancing sustainable, scientific, and community-based paddy cultivation. The scheme covers input assistance, varietal improvement, land productivity, and infrastructure development.

Major Components and Allocations:

- Input Assistance for Sustainable Rice Development – ₹5500.00 lakh
    - Support provided at ₹5500 per hectare.
    - Includes supply of quality paddy seeds, Agro Ecological Unit-based nutrient packages, and bio-control agents.

- Royalty Incentive to Landowners – ₹3000 per hectare
    - Encourages continued paddy cultivation and conservation of wetland ecosystems.

- Soil Acidity Management through Lime Application – ₹2660.00 lakh
    - Targets improvement of soil and root health in acid-prone paddy-growing regions.

- Area Expansion Initiatives – ₹300.00 lakh
    - Brings fallow land under cultivation.
    - Promotes double cropping in traditionally single-cropped regions.
    - Supports cultivation of specialty rice varieties, based on feasibility studies and KAU recommendations.

- Registered Seed Growers Programme (RSGP) – ₹125.00 lakh
    - Aims to increase the Seed Replacement Rate (SRR) to 50%.
    - Promotes seed self-sufficiency and varietal adaptation.
    - Foundation seeds produced using breeder seeds from KAU distributed free for 2500 ha.
    - Implemented with the support of Krishi Bhavans, Padasekhara Samithis, and State Seed Farms.

- Operation Double Kole (Promotion of Double Cropping in Kole Lands) – ₹50.00 lakh
    - Encourages second crop cultivation in water-retentive Kole wetlands.

- Support for Group Farming under Active Padasekhara Samithis – ₹300.00 lakh
    - Strengthens farmer collectives and shared operations.

- Infrastructure Development in Padasekharams – ₹200.00 lakh
    - Improves drainage, bunds, irrigation channels, and access roads.
    - Implemented through convergence with schemes like RKVY, RIDF, and LSGD projects.

- Foliar Application of Micronutrients – ₹195.00 lakh
    - Addresses micro-nutrient deficiencies affecting rice growth and yield.

2.3.1.1. Current Status

The scheme is being actively implemented across Kerala's major rice-growing regions. Input assistance programs have commenced with disbursement of seeds, agro ecological zone based nutrient packages, and bio-control agents. Soil acidity management is ongoing, with lime application campaigns conducted in selected panchayats. The Registered Seed Growers Programme has begun on a limited scale, and initial phases of the double cropping initiative in Kole lands have started. Padasekhara Samithis are engaged in infrastructure development works like bund maintenance and drainage clearing. Micronutrient spraying has been introduced in demonstration plots, with follow-up plans for scaling.

2.3.1.2. Limitations:

- Input supply delays are common, particularly for lime and bio-control agents, causing disruptions in planned schedules.
- The royalty incentive to landowners is not sufficient to fully prevent the conversion of paddy fields for non-agricultural purposes.
- Soil acidity management through lime application is a short-term solution, as long-term soil health improvement requires integrated interventions.
- Area expansion efforts are constrained by labor shortages, lack of mechanization at the padasekharam level, and reluctance from absentee landowners.
- The Registered Seed Growers Programme suffers from low participation, as many farmers are unfamiliar with the certification processes and consider it unprofitable compared to market sales.
- The Operation Double Kole initiative faces environmental risks such as unseasonal rainfall and waterlogging, making double cropping in Kole lands a high-risk proposition.
- The fund allocation for infrastructure works is often inadequate, considering the extensive repairs required in many padasekharams.
- Micronutrient applications are not widely Micronutrient applications are not widely adopted due to limited farmer awareness and insufficient field-level demonstrations.

2.3.2. Crop Health Management

Head of Account: 2401-00-107-78
Budget Allocation (2024–25): ₹1300.00 lakh

The Crop Health Management scheme is a vital intervention by the Government of Kerala to promote ecologically sound and climate-resilient plant protection practices. It aims to reduce dependency on synthetic chemicals while safeguarding paddy productivity through early warning systems, biological control, and field-level advisory services.

Major Components and Allocations:

- Pest and Disease Surveillance and Advisory Services – ₹135.00 lakh
  - Deployment of Pest Scouts to support Agricultural Officers in field monitoring.
  - Surveillance integrated with farm plan development to ensure timely interventions.
- Digital Pest Surveillance System – ₹20.00 lakh
  - Developed in partnership with the Kerala University of Digital Sciences.
  - Real-time monitoring and digital documentation of pest outbreaks, linked with the farmer registration portal.
- Establishment and Strengthening of Plant Health Clinics – ₹120.00 lakh
  - ₹100.00 lakh for setting up new clinics under local self-governments.
  - ₹20.00 lakh to upgrade and strengthen existing clinics across districts.
- Upgradation of Parasite Breeding Stations – ₹50.00 lakh
  - Supports production of bio-control agents essential for integrated pest management in paddy ecosystems.
- Rodent Control Campaign – ₹25.00 lakh
  - Statewide implementation to mitigate rodent damage in paddy fields.
- Development of Non-lethal Crop Protection Technologies – ₹200.00 lakh
  - Focused on reducing crop damage caused by wild animal attacks using ecological and technological methods.

2.3.2.1. Current Status:

Pest scouts have been deployed in key rice-growing areas, and field-level pest surveillance is linked to the farm plan process. Digital pest surveillance tools have been launched but are in early-stage use. Plant Health Clinics are being upgraded with new diagnostic equipment, and parasite breeding stations are producing bio-control agents like Trichogramma. Rodent control campaigns have been conducted prior to the harvest season. Trials of non-lethal wild animal deterrents are ongoing in selected high-conflict zones.

2.3.2.2. Limitations:

- Digital pest surveillance adoption is low, especially among older farmers, due to limited digital literacy.
- Bio-control agent production is inadequate to meet the growing demand, resulting in continued chemical dependency.
- Rodent control campaigns are periodic, not sustained, leading to population rebounds post-campaign.
- Wild animal deterrent methods remain in pilot phases, with no large-scale rollout yet.
- Agri-extension manpower is insufficient to provide consistent advisory services for pest management.

2.3.3. State Crop Insurance Scheme

Head of Account: 2401-00-110-82
Budget Allocation (2024–25): ₹3314.00 lakh

The State Crop Insurance Scheme is a dedicated risk mitigation initiative by the Government of Kerala to protect farmers from income loss resulting from natural calamities. The scheme operates alongside national-level insurance programs but provides additional state-level support, particularly for paddy farmers vulnerable to climatic shocks. It aims to stabilize farmer incomes and ensure continuity of cultivation even in disaster-prone areas.

Major Components:

- Crop Insurance Fund Management:
  A contributory fund jointly operated by the government and participating farmers.
- Farmer Registration and Premium Collection:
  Farmers contribute a nominal registration fee and premium to enroll in the scheme.
- Coverage for Crop Losses:
  Compensation is provided for yield reduction due to floods, droughts, pest/disease outbreaks, and other climatic adversities.
- Assessment and Settlement of Claims:
  Crop loss verification is conducted by joint inspection teams, followed by settlement of eligible claims from the insurance fund.
- Integration with Central Schemes:
  The scheme complements central programs like PMFBY to ensure broader risk coverage.

2.3.3.1. Current Status:

The State Crop Insurance Scheme remains operational in 2024–25, with efforts to expand farmer enrollment through Krishi Bhavans, Padasekhara Samithis, and agricultural extension services. District-level awareness campaigns have been launched to encourage participation, especially in regions prone to floods and unseasonal rains. Digital registration processes are being adopted in phases, though manual systems are still prevalent in remote areas. Claims from the previous seasons are under processing, and compensation has been disbursed in selected districts where calamity assessments have been completed. However, the scheme continues to face several operational and structural challenges.

2.3.3.2. Limitations:

- Limited coverage and enrollment due to lack of awareness, cumbersome registration processes, and exclusion of non-notified crops or areas.
- Delays in claim settlement arising from manual assessment methods, insufficient digital infrastructure, and coordination gaps.
- Financial and operational constraints, including inadequate fund reserves during successive disasters and outdated risk assessment models.
- Compensation is not guaranteed for all losses, as payouts are only provided when yield falls below pre-defined thresholds, leaving minor or moderate losses uncovered.

2.3.4. Organic Farming and Good Agricultural Practices (GAP)

Head of Account: 2401-00-105-85
Budget Allocation (2024–25): ₹600.00 lakh

This scheme promotes the adoption of organic farming systems and GAP to ensure food safety, environmental health, and sustainable crop production, particularly in paddy-based systems.

Major Components and Allocations:

- Promotion of Organic/GAP Cultivation in Certified Clusters – ₹350.00 lakh
  - * Implementation aligned with protocols

from the Kerala Agricultural University.
    * Focuses on major crops including rice, supported by group-based and area-based certifications.

- On-farm Bio-input and Organic Manure Production – ₹80.00 lakh
    * Supports composting, biogas installation, and production of plant-based formulations.
    * Encourages substitution of synthetic inputs in rice cultivation.

- Safe-to-Eat Food Production under Organic Standards – ₹95.00 lakh
    * Ensures chemical-free paddy production and builds consumer confidence in organic rice.

- Support to SHGs for Organic Fruits and Vegetables Cultivation – ₹75.00 lakh
    * Includes integrated farming models where rice may be cultivated alongside horticultural crops.

2.3.4.1. Current Status:

Certified organic clusters have been established in selected districts, with technical guidance provided by Kerala Agricultural University. Self Help Group (SHG) based initiatives for on-farm bio-input production have been supported. The Safe-to-Eat food initiative is being implemented in pilot zones, focusing on paddy and vegetables. Integrated farming systems are promoted under this scheme to diversify rice-based cultivation models.

2.3.4.2. Limitations:

- Certification procedures are complex and time-consuming, discouraging smallholder participation.
- Bio-input supply systems are underdeveloped, leading to inconsistent availability of quality organic inputs.
- Organic rice faces marketability issues due to weak branding and limited consumer awareness.
- The cluster approach does not cover all regions, restricting the scheme's reach.
- Monitoring of GAP compliance is difficult because of a shortage of field-level extension staff.

2.3.5. Development of Production and Technology Support

Head of Account: 2401-00-109-56
Budget Allocation (2024–25): ₹500.00 lakh

This scheme enhances the transfer of farm technologies, scientific protocols, and data systems relevant to sustainable rice farming. It is implemented by the Directorate of Extension of Kerala Agricultural University (KAU).

Major Components and Allocations:

- Development of Technical Modules and Extension Protocols by KAU – ₹100.00 lakh
- Includes sustainable rice cultivation practices, field demonstrations, and farmer field schools.
- Maintenance of Integrated Digital Agriculture Platform – ₹50.00 lakh
    * Real-time monitoring of rice production parameters in collaboration with the Digital University of Kerala.

- Support for Formation and Strengthening of FPOs
    * Encourages collective paddy cultivation, input procurement, and market linkage through FPOs.

2.3.5.1. Current Status:

Kerala Agricultural University has developed technical modules for climate-resilient rice farming, which are being demonstrated in farmer fields. The Integrated Digital Agriculture Platform is partially operational, with real-time data collection in pilot blocks. FPOs are being encouraged to take up sustainable rice cultivation models and collective marketing strategies.

2.3.5.2. Limitations:

- Extension services have limited outreach, especially in tribal and remote rice-growing areas.
- Digital platforms are underutilized, as many farmers prefer traditional extension methods.
- FPOs face operational hurdles, including leadership gaps, financial sustainability issues, and limited negotiation power in markets.
- Follow-up field visits are inadequate, leading to slow technology adoption.

2.3.6. Supply Chain and Value Chain Development under Farm Plan Development Programme

Head of Account: 2401-00-111-97
Budget Allocation (2024–25): ₹500.00 lakh

Focused on post-harvest efficiency, this scheme supports the creation of decentralized value chains in rice farming, reducing transaction costs and increasing farmer incomes through collective marketing.

Major Components and Allocations:

- Development of Hub-and-Spoke Aggregation Models
  - Links local production units with centralized aggregation, storage, and marketing hubs.
  - Managed by FPOs, cooperatives, or Kudumbashree units.
- One-time Capital Assistance for Post-Harvest Infrastructure
  - 50% reimbursement for weighing machines, solar panels, dryers, and grading units.
- Integration with Digital Platforms for Price Discovery
  - Facilitates producer registration, demand aggregation, and digital payments to ensure transparency and timely returns.

2.3.6.1. Current Status:

Pilot implementation of hub-and-spoke aggregation models has started in select locations. Post-harvest equipment like solar dryers and grading machines are being subsidized. Digital platforms for price discovery are in beta testing, linked to producer registration drives.

2.3.6.2. Limitations:

- Post-harvest infrastructure is inadequate, particularly for storage, drying, and aggregation at the local level.
- Adoption of digital tools is low among older farmers who are unfamiliar with online systems.
- Collective marketing is hampered by trust deficits, as farmers are hesitant to pool produce due to previous experiences with price volatility.
- High initial investment requirements limit smallholder participation, despite the subsidy support.

2.3.7. International Research and Training Centre for Below Sea Level Farming, Kuttanad

Head of Account: 2415-01-004-88
Budget Allocation (2024–25): ₹30.00 lakh

This specialized centre serves the unique below-sea-level paddy cultivation region of Kuttanad. It focuses on region-specific adaptive research, field problem resolution, and technology dissemination.

Major Focus Areas:

- Field-Level Research and Innovation for Kuttanad
  - Addresses waterlogging, salinity, and bund management challenges specific to the region.
- Knowledge Transfer to Local Farming Communities
  - Offers training and technical support tailored to below-sea-level rice systems.

2.3.7.1. Current Status:

Research activities specific to below-sea-level rice ecosystems have commenced, focusing on waterlogging, salinity management, and pest dynamics. Training programs for farmers on adaptive rice farming practices have been organized periodically.

2.3.7.2. Limitations:

- Budget allocation is minimal, restricting the scale and depth of research programs.
- Staffing is inadequate, with dependency on project-based researchers rather than permanent staff.
- Transfer of knowledge is slow, with limited extension to all farmers in the region.
- Geographic focus is narrow, limiting the scheme's impact beyond the core Kuttanad area.

2.3.8. Strengthening Agricultural Extension

Head of Account: 2401-00-109-80
Budget Allocation (2024–25): ₹2503.00 lakh

Robust extension services are crucial for the dissemination of sustainable agricultural practices, including those specific to rice. In 2024–25, a total allocation of ₹2503.00 lakh has been earmarked to strengthen field-level extension infrastructure, technical advisory systems, and farmer outreach mechanisms. Key interventions relevant to sustainable rice farming include:

- Strengthening of Agricultural Technology Management Agency (ATMA) operations and support systems (₹320.00 lakh), enabling structured field guidance and handholding.
- Preparation of monthly crop-specific technology advisories by LEADS (₹300.00 lakh), supporting informed decision-making in paddy cultivation.
- Promotion of participatory activities such as seminars, farmer meets, and agro festivals (₹50.00 lakh), many of which are held in paddy-focused regions.
- Modernization of Krishi Bhavans into Smart Krishi Bhavans (₹1000.00 lakh), with improved advisory, digital mapping, plant health services, and e-governance tools—all of which enhance access to sustainable input and crop management systems.
- Implementation of "Agroclinics" at the ward level and "Krishi Darshan" programmes (₹107.00 lakh total), offering locally responsive platforms to resolve rice crop issues.
- Support for the "Njangalum Krishiyilekku" campaign (₹375.00 lakh), encouraging wider participation in sustainable agricultural practices, including paddy re-engagement in fallow regions.

2.3.8.1. Current Status:

ATMA programs are being implemented with farmer training. Smart Krishi Bhavan projects are in progress, improving ICT access at the panchayat level. Agroclinics and ward-level Krishi Darshan programs are operational in many areas.

2.3.8.2. Limitations:

- Extension officers are overburdened, resulting in reduced field interaction.
- Smart Krishi Bhavans face connectivity issues, particularly in rural and coastal areas.
- Agroclinics require capacity building to handle the complexity of modern rice pest and disease management.
- Localized advisories are not always timely, due to delays in data aggregation and dissemination.

2.3.9. Support to Farm Mechanization

Head of Account: 2401-00-113-83 & 4401-00-113-98
Budget Allocation (2024–25): ₹1695.00 lakh

Mechanization is a key enabler of sustainable rice production, especially in the context of labour shortages and the need for timely farm operations. Under this scheme, an outlay of ₹1695.00 lakh has been provided to expand mechanization access through Karshika Karma Senas, Agro Service Centres, and Custom Hiring Centres. The project aims to converge these into unified "Krishisree Centres," offering end-to-end mechanization support at the panchayat level.

Specific components beneficial to rice cultivation include:

- Establishment and strengthening of Krishisree Centres and Karma Senas (₹800.00 lakh).
- Top-up subsidy for group-based machinery purchases, including through FPOs (₹100.00 lakh).
- Provision of group accident insurance for machinery operators (₹20.00 lakh).
- Internship programme for VHSE students in agriculture, aiding knowledge exchange at the grassroots level (₹280.00 lakh).
- Operational support to Kerala State Agricultural Mechanization Mission (KSAMM) (₹200.00 lakh), ensuring monitoring, coordination, and real-time equipment performance tracking.
- Business planning support to make the centres financially sustainable, thereby improving the reliability and affordability of services for rice farmers.

2.3.9.1. Current Status:

Krishisree Centres and Karma Senas are providing mechanization services at the panchayat level. VHSE internships have started, contributing to operator skill development. Group machinery procurement is also operational through FPOs and farmer groups.

2.3.9.2. Limitations:

- High machinery maintenance costs deter continuous service delivery by Krishisree Centres and Custom Hiring Centres.
- Uneven mechanization adoption, with remote and fragmented areas lagging due to logistical difficulties and lack of infrastructure.
- Shortage of trained operators limits the optimal use and upkeep of machinery.
- High costs of machinery, even after subsidies, remain a barrier for small and marginal farmers.
- Unsuitability of large machinery for small landholdings, especially in Kerala's fragmented paddy fields, restricts its practical utility even when equipment is available.

2.3.10. Development of Agriculture Sector in Kuttanad and RIDF

Head of Account: 2401-00-119-78 & 2401-00-119-76
Budget Allocation: ₹3600.00 lakh

The Kuttanad region, known for its below-sea-level paddy farming, requires intensive water and land management to sustain rice cultivation. This scheme, with a total allocation of ₹3600.00 lakh, focuses on improving farm infrastructure and operational feasibility in the region.

The core component involves the replacement of traditional "petti and para" water lifting systems with energy-efficient vertical axial flow and submersible pumps (10–50 HP), including construction of elevated platforms for installation. This directly supports the dewatering operations essential for paddy field preparation and crop establishment.

Out of the total outlay, ₹200.00 lakh is specifically allocated for padasekharam infrastructure development. The scheme also promotes:

- Convergence with ongoing schemes like RKVY, RIDF, and LSGD for coordinated infrastructure implementation.
- Adoption of an approved crop calendar for timely cultivation.
- Facilitation of short-duration rice varieties, improving yield predictability under water-stressed or delayed sowing conditions.

2.3.10.1 Current Status:

Vertical axial flow pumps and submersible pumps are being installed to replace traditional dewatering systems. Infrastructure works like bund strengthening and canal cleaning are being implemented through convergence with RKVY, RIDF, and LSGD.

2.3.10.2. Limitations:

- Operational costs for new pump systems are high, increasing the burden on padasekharam committees.
- Maintenance and servicing of pumps are irregular, affecting long-term sustainability.
- Inter-departmental coordination is often slow, leading to project delays.
- Farmers are reluctant to adopt short-duration rice varieties, fearing yield penalties.

2.3.11. Contingency Programme to Meet Natural Calamities and Pest/Disease Outbreaks

Head of Account: 2401-00-800-91
Budget Allocation: ₹750.00 lakh

Climate-induced shocks and pest/disease outbreaks pose increasing threats to rice farming. The Contingency Programme aims to provide rapid-response support in such events, with a total outlay of ₹750.00 lakh. Relevant provisions include:

- Creation and maintenance of buffer stocks of short-duration paddy varieties for immediate post-calamity planting.
- Assistance for strengthening bunds and clearing debris in affected paddy fields.
- Emergency crop health interventions in the event of widespread pest or disease endemic conditions.

2.3.11.1. Current Status:

Buffer seed stocks are maintained at district levels. Emergency response teams are activated during floods and pest outbreaks. Post-disaster field rehabilitation is supported with input assistance.

2.3.11.2. Limitations:

- Response times during major disasters are sometimes delayed, impacting timely replanting.
- Farmer awareness about contingency protocols is low, leading to underutilization.
- Seed buffer stocks are not uniformly distributed,

causing supply gaps in certain regions.
- Proactive climate risk planning is limited, with most interventions being reactive.

2.3.12. Kerala Climate Resilient Agri Value Chain Modernization Project (KERA)

Head of Account: 2401-00-111-95 (01)
Budget Allocation: ₹10,000.00 lakh

Launched in 2024–25, the KERA project is a major World Bank-supported initiative aimed at transforming Kerala's agricultural sector through climate resilience, value chain modernization, and inclusive economic development. It places a strong emphasis on supporting smallholder farmers, including paddy cultivators, in adapting to climate change and improving market integration. This large-scale, multi-stakeholder initiative integrates sustainability with commercialization, which is critical for long-term viability of rice farming systems.

The project comprises the following major components:

- Climate resilience and mitigation in agriculture, specifically designed to buffer production systems like rice against extreme weather variability.
- Smallholder commercialization and value addition, through support to FPOs, MSMEs, startups, and SHGs, including those in rice farming and processing.
- Partnership with the Department of Industries, particularly in the rice value chain, for facilitating post-harvest handling, branding, and marketing.
- Contingent Emergency Response Component (CERC) to respond to climate shocks and natural disasters—frequent risks in rice-growing ecosystems.
- Potential climate finance mobilization, enabling access to future funding mechanisms aimed at low-carbon and adaptive agriculture.

2.3.12.1. Current Status:

KERA has initiated stakeholder consultations, with FPO strengthening and post-harvest support planned for the first phase. Climate resilience modules are being developed in partnership with line departments.

2.3.12.2. Limitations:

- The project is still in early phases, with limited on-ground execution visible so far.
- Complex project architecture may slow implementation, due to multi-agency coordination challenges.
- Climate finance mechanisms are yet to be fully developed, delaying access to international funds.
- Convergence with other schemes is still under negotiation, affecting field-level rollout.

2.3.13. Biodiversity and Local Germplasm Conservation and Promotion

Head of Account: 2401-00-103-77
Budget Allocation: ₹25.00 lakh

This scheme focuses on conserving indigenous and traditional crop varieties, especially those cultivated in tribal belts and fragile agro-ecosystems. Paddy is one of the primary target crops under this initiative, given the wealth of traditional rice varieties still cultivated across Kerala's wetlands, uplands, and tribal regions.

Key components of the scheme include:

- In-situ conservation of local rice varieties, especially in tribal areas through cultivation and seed multiplication.
- Support to tribal communities and farmer clusters for the cultivation and regeneration of traditional paddy strains adapted to local soil and climatic conditions.
- Seed procurement and distribution, facilitating the spread of heirloom rice varieties to other districts for agro-ecological diversification.
- Maintenance of an indigenous variety registry by the Organic Farming Cell at the Directorate of Agriculture, including paddy and millets.

2.3.13.1. Current Status:

In-situ conservation of traditional rice varieties is being implemented in tribal belts.

2.3.13.2. Limitations:

- Budget allocation is very low, restricting the scale of conservation initiatives.
- Limited farmer awareness outside target areas,

causing slow spread of traditional varieties.
- Weak market development for indigenous rice, reducing farmer incentives for conservation.
- Seed distribution to other districts is minimal, limiting agroecological diversification.

2.4. REVIEW OF CENTRAL SECTOR AND CENTRALLY SPONSORED SCHEMES SUPPORTING SUSTAINABLE RICE DEVELOPMENT

2.4.1. Centrally Sponsored Schemes Under the Umbrella of Krishi Unnati Yojana

State Share: ₹7700.00 lakh (2024–25)

These schemes are co-funded by the Government of India (60%) and the Government of Kerala (40%) and cover major thematic areas relevant to rice farming—from input management and sustainable agriculture to infrastructure and market linkages.

Relevant Sub-Schemes:

- National Food Security Mission (NFSM):
    * Supports increased rice production via seed distribution, site-specific nutrient management, and integrated pest management.
    * Promotes climate-resilient practices and input optimization.

- Rashtriya Krishi Vikas Yojana (RKVY):
    * Enables Kerala to develop customized DPRs for rice sector support—e.g., irrigation, mechanization, and post-harvest infrastructure.
    * ₹1500.00 lakh is allocated as state share for 2024–25.

- Paramparagat Krishi Vikas Yojana (PKVY):
    * Focuses on cluster-based organic rice production.
    * Provides ₹31,500 per hectare (including ₹15,000 as DBT incentive to farmers) for adopting organic practices.

- Sub-Mission on Agricultural Mechanization (SMAM):
    * Aids procurement of paddy-specific farm machinery.
    * Promotes Custom Hiring Centres (CHCs), including drone services for pesticide and nutrient application.

- Sub-Mission on Agriculture Extension (SMAE):
    * Implements ATMA model in Kerala to strengthen rice-related advisory systems.
    * Leverages digital platforms like VISTAAR and Apurva AI to deliver weather-based and crop-stage-specific advisories.

2.4.1.1. Current Status:

Kerala is actively implementing NFSM, RKVY, PKVY, SMAE, and SMAM through decentralized district-level plans. Emphasis is given to seed replacement, organic cluster formation, mechanization, and extension digitalization.

2.4.1.2. Limitations:

- Organic cluster formation under PKVY is progressing slowly due to limited market access for organic rice.
- Mechanization support remains skewed towards large machinery, limiting benefits for smallholder farmers.
- Adoption of ATMA-based extension models faces constraints due to staff shortages and lack of digital literacy among field officers.

2.4.2. Pradhan Mantri Fasal Bima Yojana (PMFBY)

Launched in 2016, the Pradhan Mantri Fasal Bima Yojana is a key national initiative aimed at providing affordable and comprehensive crop insurance coverage. The scheme serves as an essential risk mitigation mechanism for paddy farmers in Kerala, particularly those affected by frequent climate uncertainties and natural disasters.

- Provides insurance cover against all non-preventable risks from pre-sowing to post-harvest stages.
- Ensures direct and timely claim settlements through Direct Benefit Transfer (DBT).
- Plays a significant role in building climate resilience among paddy farmers, especially in flood- and drought-prone regions.
- Encourages farmer confidence in investing in higher productivity and sustainable inputs.

2.4.2.1. Current Status:

The PMFBY is operational across all rice-growing districts in Kerala. Enrollment has increased, particularly in flood-prone areas. Settlements are improving with Direct Benefit Transfer (DBT) mechanisms.

2.4.2.2. Limitations:

- Delay in claim processing remains an issue despite DBT linkage.
- Crop loss assessments sometimes do not capture partial damages accurately.
- High premium rates are reported for certain regions, discouraging participation.
- Not all stages of crop loss (like early-stage failure) are fully compensated.

2.4.3. Agriculture Infrastructure Fund (AIF)

Introduced in 2020 under the Atmanirbhar Bharat package, the Agriculture Infrastructure Fund is a long-term debt financing facility designed to improve post-harvest management and community-based infrastructure. In Kerala, the scheme is particularly relevant to paddy cultivation due to the pressing need for decentralized storage, primary processing, and collective value addition.

- Offers interest subvention of 3% per annum on loans and credit guarantee coverage for loans up to ₹2 crore.
- Supports investments by FPOs, Primary Agricultural Credit Societies (PACS), Self Help Groups (SHGs), and cooperative institutions in setting up rice mills, drying yards, storage godowns, and rice value chain hubs.
- Promotes public-private partnerships and convergence with state-led rice development programmes.
- Facilitates modern infrastructure for rice aggregation, minimizing post-harvest losses and enhancing market competitiveness.

2.4.3.1. Current Status:

FPOs, PACS, and cooperatives have started availing AIF loans for rice milling units, drying yards, and storage infrastructure in select districts. State-level convergence efforts are underway.

2.4.3.2. Limitations:

- Complex loan application processes deter small FPOs from applying.
- Risk-averse lending behavior by banks delays infrastructure creation.
- Lack of professional management capacity in FPOs affects project sustainability.

2.4.4. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) – Per Drop More Crop Component

Launched in 2015, PMKSY aims to enhance water use efficiency and ensure equitable irrigation access through micro-irrigation systems. The "Per Drop More Crop" component is particularly applicable to Kerala's rice-growing regions where water management is increasingly critical.

- Promotes adoption of precision irrigation technologies (drip, sprinkler) even in semi-wet rice systems and high water table areas.
- Facilitates the creation of micro-level water harvesting and distribution infrastructure.
- Helps address water scarcity in tail-end areas of irrigation canals and improves productivity under climate stress.
- Contributes to sustainable water governance in rice agro-ecosystems through convergence with watershed and canal rehabilitation initiatives.

2.4.4.1. Current Status:

Micro-irrigation adoption in rice is limited but pilot projects are ongoing in semi-wet rice systems in Palakkad and Alappuzha.

2.4.4.2. Limitations:

- Paddy is traditionally a flood-irrigated crop; farmers are hesitant to shift to micro-irrigation.
- Installation of drip and sprinkler systems is technically challenging in wetland paddy fields.
- The cost of micro-irrigation systems remains high for smallholders despite subsidies.

2.4.5. Soil Health Card (SHC) Scheme

The Soil Health Card scheme was launched in 2015 to improve scientific nutrient management practices at the farm level. In Kerala, where intensive paddy cultivation has led to concerns over soil degradation, this initiative supports sustainable input use.

- Provides individualized soil health reports with crop- and plot-specific fertilizer recommendations.
- Promotes balanced use of fertilizers and micronutrients, reducing input costs for paddy farmers.
- Facilitates long-term improvement in soil fertility and organic matter in rice ecosystems.
- Enables farmers to align input use with AEU (Agro-Ecological Unit)-based advisories from Kerala Agricultural University and Krishi Bhavans.

2.4.5.1 Current Status:

Soil sampling and distribution of health cards are conducted periodically. The initiative is integrated with Agro Ecological Unit (AEU)-based fertilizer recommendations.

2.4.5.2. Limitations:

- Follow-up advisory services are inadequate; farmers often do not implement recommendations.
- Delay in sample analysis reduces relevance during the crop season.
- Digital accessibility of soil health data is still limited in many regions.

2.4.6. Modified Interest Subvention Scheme (MISS)

Revised and expanded in 2020, the Modified Interest Subvention Scheme seeks to make short-term credit more accessible and affordable for small and marginal farmers engaged in crop cultivation, including paddy.

- Offers crop loans up to ₹3 lakh at 7% annual interest, with an additional 3% subvention for prompt repayment—bringing the effective rate down to 4%.
- Extends concessional credit to cover post-harvest needs through Negotiable Warehouse Receipts (NWRs), supporting rice farmers to avoid distress sales.
- Acts as a buffer against climate and price volatility by enabling timely access to working capital.
- Integrates with Kisan Credit Card (KCC) systems to streamline credit access for tenant and marginal paddy farmers.

2.4.6.1. Current Status:

Crop loans under KCC continue to be the primary credit source for rice farmers. The prompt repayment incentive is helping maintain low-interest credit flows.

2.4.6.2. Limitations:

- Tenant farmers face difficulty in accessing KCC-linked loans due to lack of land ownership documentation.
- The scheme covers short-term credit but not long-term mechanization or infrastructure investments.
- Loan disbursement delays are reported in some districts, affecting timely input procurement.

2.4.7. Formation and Promotion of 10,000 Farmer Producer Organizations (FPOs)

Launched in 2020, this national programme promotes collectivization of farmers through the formation of legally registered FPOs. It is especially beneficial to rice farmers in Kerala, who often cultivate fragmented holdings in low-margin environments.

- Each FPO is eligible for a financial package of up to ₹18 lakh over three years, covering handholding, governance, and business planning.
- Offers an equity grant of up to ₹15 lakh and credit guarantee support of ₹2 crore to enable access to institutional credit.
- Encourages FPOs to aggregate rice, procure inputs, operate paddy processing units, and market rice collectively for better price realization.
- FPOs are onboarded on the National Agriculture Market (e-NAM) for transparent, online trading of rice and other crops.

2.4.7.1. Current Status:

Several rice-focused FPOs have been formed in Kerala under this initiative. They are engaged in seed procurement, marketing, and value addition.

2.4.7.2. Limitations:

- Many FPOs lack professional management and face governance issues.
- Market linkages for paddy and rice value-added products are underdeveloped.
- Financial sustainability beyond grant support is a concern for newly formed FPOs.

2.4.8. Digital Agriculture & National e-Governance Plan in Agriculture (NeGPA)

NeGPA, launched in 2010 and currently being upgraded under the "Digital Agriculture Mission," supports the development of farmer-centric digital infrastructure. Kerala is actively implementing components of this mission to improve paddy farming outcomes through precision advisories.

- Facilitates geo-referencing of rice fields, farmer profiling, and digitized land records for effective input targeting.
- Supports decision-making through dashboards integrating real-time weather data, crop monitoring, and advisory systems.

- Enables seamless delivery of input subsidies, crop insurance, and soil health cards through integrated platforms.
- Encourages use of AI-based tools for pest prediction, yield forecasting, and water budgeting tailored to paddy fields.

2.4.8.1. Current Status:

Kerala is actively implementing NeGPA components such as land digitization, e-subsidy delivery, and digital pest surveillance. Integration with Apurva AI and VISTAAR advisory platforms is ongoing.

2.4.8.2. Limitations:

- Incomplete digitization of farmer records delays full rollout of digital services.
- Farmers in remote areas face challenges in using digital tools due to limited connectivity and digital literacy.
- Integration of real-time field data with advisory platforms is still at an early stage.

2.5. REVIEW OF KEY PROJECTS AND STUDIES ON CLIMATE-RESILIENT PADDY CULTIVATION IN KERALA

Understanding the scientific and socio-economic dimensions of climate-resilient paddy cultivation is essential for designing effective adaptation strategies. A number of recent studies in Kerala have focused on the impact of climatic variability on paddy yields, innovations in submergence-tolerant varieties, and institutional responses to agroecological stress. This section reviews six key studies that provide valuable insights into the challenges and opportunities associated with climate-resilient rice farming in the state.

2.5.1. National Initiative on Climate Resilient Agriculture (NICRA)

The Indian Council of Agricultural Research (ICAR) initiated NICRA to strengthen the resilience of Indian agriculture—covering crops, livestock, and fisheries—against climate variability and long-term change. It focuses on developing improved production and risk management technologies and demonstrating integrated, site-specific packages on farmers' fields.

- Demonstrations are implemented through 100 Krishi Vigyan Kendras (KVKs) nationwide.
- The programme is coordinated by CRIDA and Zonal Project Directorates.
- In Kerala, Alappuzha is the only NICRA-covered district.
- The intervention site was Muttar village, located in Veliyanad block of the Kuttanad region.

The Kuttanad region spans Alappuzha, Kottayam, and Pathanamthitta districts. It is one of the very few places globally where agriculture is practiced at 1.2 to 3 meters below mean sea level. This region is Kerala's primary rice-producing zone and holds historical and geographical importance.

NICRA implementation in Kuttanad targeted this unusual farming system. The first phase was piloted in Muttar village, which borders Ramankari, Paippad, Nedumpuram, and Thalavadi.
Key features of Muttar:

- Lies up to 2 meters below MSL, frequently submerged during monsoons.
- Paddy is grown in padasekharams from November to March; fields remain waterlogged the rest of the year.
- Average paddy productivity is 4.66 t/ha—higher than the district average due to silt deposition during floods.
- Canal networks support dewatering and irrigation.
- Allied activities: dairy, goat rearing, poultry, and inland fisheries

In a later phase, Thalavady village was included due to similar ecological vulnerabilities.

2.5.1.1. NICRA Technology Modules and Field Interventions

Module I: Natural Resource Management
Composting of Aquatic Weeds Using EM Solution
In the off-season, aquatic weeds such as water hyacinth accumulate in the waterlogged fields. These weeds were converted into compost using an EM (Effective Microorganism) solution.

- Semi-dried weeds were stacked in 10×2×1 m beds.
- Each layer was treated with cow dung slurry and EM solution.
- Composting completed within 45–50 days.

- Compost was used by women's SHGs for banana and vegetable cultivation.

Impact:

- Transformed waste into resources, reducing weed menace.
- Muttar became the first panchayat in Alappuzha to use MGNREGS for weed composting (2014–15).
- The practice was later adopted by other panchayats as well.

Module II: Crop Production

Promotion of Climate-Resilient and Resource-Conserving Technologies in Paddy. This module addressed several key issues faced by local farmers:

- Excessive seed use due to broadcasting.
- High fertilizer and pesticide inputs.
- Soil acidity and poor nutrient management.

Interventions:

- Mechanization:
  Drum seeders replaced broadcasting, reducing seed use from 150 kg/ha to 50 kg/ha.
- Soil Health Management:
  Application of lime/dolomite (600 kg/ha) based on soil testing helped correct acidity (pH 4.5–5.5).
- Eco-Friendly Pest and Disease Management:

  * Seed treatment and foliar application of Pseudomonas.
  * Use of trichocards and fish amino acid sprays.

Outcomes:

- Demonstrated over 118.2 ha with 161 farmer participants in five years.
- Resulted in substantial reduction in seed, fertilizer, and pesticide usage.
- Lowered input costs and improved crop health.

2.5.2. Study 1: Climate Variability and Paddy Yield

(Basheer K.K. & Seena Devi, 2022)

This study analyzed the effects of seasonal climatic fluctuations on paddy yield in Kerala using the Just and Pope production function. The findings revealed that winter and summer temperatures had a positive influence on yield, whereas excessive autumn rainfall contributed to reduced productivity. Additionally, the increasing variability of monsoon rainfall was associated with heightened yield instability. The authors recommend the development of temperature- and flood-resilient rice varieties and the promotion of conservation agriculture practices to mitigate future climate risks.

2.5.3. Study 2: Declining Yield in Kollengode

(K.R. Sreeni & Nirmala Vasudevan, 2024)

Focusing on Kollengode village in Palakkad district, this study examined the impact of delayed monsoons and reduced rainfall on traditional cropping cycles. It reported significant yield reductions due to water stress during critical growth stages. Furthermore, the study identified rising minimum temperatures and a declining diurnal temperature range as factors that disrupt plant respiration and affect crop performance. Suggested interventions include improved irrigation infrastructure, rainwater harvesting systems, soil moisture conservation techniques such as mulching, and an economic assessment of local irrigation strategies.

2.5.4. Study 3: Rice Breeding for Submergence-Prone Areas

(A.K. A. et al., 2025)

This breeding initiative, conducted at the M.S. Swaminathan Rice Research Station, aimed to develop varieties suitable for the unique below-sea-level conditions of Kuttanad. Two medium-duration, non-lodging, dormancy-enabled varieties were released: KAUM 179-1 (red kernel, moderately submergence-tolerant) and KAUM 180-2 (white kernel, slightly submergence-tolerant). These varieties were specifically developed to maintain yield under erratic monsoon and flood-prone conditions, offering a practical solution to the climatic challenges faced by rice farmers in this lowland ecosystem.

2.5.5. Study 4: Climate Resilience in Kainakary

(Annie Thomas & Aaron George, 2023)

A socio-economic study conducted in the flood-prone village of Kainakary revealed extensive livelihood disruption due to recurrent flooding. Survey data indicated that 79% of households suffered property damage, while 93% experienced loss of crops or income, particularly among paddy farmers. The study emphasizes the importance of building resilience through community-level interventions, including crop insurance schemes, the introduction of climate-resilient seed varieties, the establishment of seed banks, and the development of early warning systems and critical infrastructure to reduce future vulnerability.

2.5.6. Study 5: Changing Dynamics in Kerala's Paddy Sector.

(Basheer K.K., Muneer Babu M., Biju Abraham, 2023)
This study analyzed the broader structural changes affecting paddy cultivation in Kerala. Labour shortages, exposure to climate risks, and decreasing profitability have led to a shift toward alternative crops such as coconut, areca nut, and banana, resulting in reduced paddy acreage. However, collective farming groups like Padashekhara Samithies and Kudumbashree Joint Liability Groups (JLGs) have helped sustain rice production in many areas. The authors call for the promotion of sustainable, climate-resilient farming practices, conservation of traditional rice varieties, and greater mechanization to improve long-term viability.

2.5.7. Study 6: Sustainability of Traditional Rice Cultivation

(Krishnankutty et al. , 2021)
This study assessed the viability of traditional rice cultivation systems from both economic and social perspectives. Although traditional practices were found to be less profitable under modern market conditions, they remained sustainable in family-owned farms due to low external dependence and cultural continuity. Farmers practicing these methods were generally older and less integrated with formal markets but expressed satisfaction with their agricultural systems. The study suggests that institutional support and enhanced market access could help revive and sustain traditional rice farming while preserving biodiversity and community identity.

2.6. SUMMARY ANALYSIS OF POLICY AND TECHNOLOGICAL INTERVENTIONS SUPPORTING SUSTAINABLE RICE CULTIVATION IN KERALA

The schemes and projects implemented during the financial year 2024–25 reflects the Government of Kerala's strategic commitment to advancing sustainable and climate-resilient rice farming. These interventions, supported both at the state and central levels, are aligned with multiple dimensions of sustainability, encompassing ecological conservation, economic support, technological advancement, and institutional development. While several of these initiatives have demonstrated significant progress in enabling transitions to resilient farming systems, critical implementation gaps and structural limitations remain.

The following matrix provides a synthesized evaluation of the major policy and technological interventions, categorized by key thematic pillars. It offers an objective assessment of the constraints associated with current schemes and programmes, thereby identifying areas for improvement and future policy refinement:

Table 2.1. Summary of limitations in central and state schemes for sustainable rice development in Kerala

Aspect	Relevant Schemes	Limitations
Ecological Sustainability	Rice Development Scheme (Soil Acidity Management, Bio-control Promotion), Crop Health Management, Organic Farming & GAP, Biodiversity & Local Germplasm Conservation, PKVY, SHC Scheme	-Ecological practices remain niche and are not mainstreamed. -Enforcement of sustainable input use is weak. -Grassroots-level behavioral change towards eco-friendly practices is slow.
Economic Viability	Rice Development Scheme (Input Assistance, Mechanization, Area Expansion), Supply Chain & Value Chain Development Programme, MISS, AIF, PMFBY, Formation and Promotion of FPOs	-Crop insurance often covers only complete crop loss, discouraging salvage harvesting of partially damaged crops. -High cost of machinery limits use among smallholders; many machines are unsuitable for small landholdings even when available.
Technological Integration	Development of Production and Technology Support, Digital Agriculture & NeGPA, SMAM, SMAE	-Digital infrastructure gaps exist in rural areas. -Limited digital literacy restricts use of advisory apps and platforms. -Maintenance costs and shortage of trained operators affect mechanization efficiency.
Climate Resilience	NFSM, PMFBY, PMKSY, KERA, NICRA	-Limited geographic reach of climate-resilient interventions. -Poor coordination between climate risk schemes. -Crop insurance schemes do not adequately compensate for partial losses. -Adoption of short-duration rice varieties is slow despite recommendations.
Institutional Support	Strengthening Agricultural Extension, Operation Double Kole, Padasekhara Samithi Support, Formation and Promotion of FPOs, Development of Agriculture Sector in Kuttanad	-Lack of coordination between departments leads to fragmented and delayed implementation. -Some Padasekharams lack capacity for technology adoption. -Real-time data sharing between agencies remains weak, affecting coordinated action.

Social Inclusion	Organic Farming & GAP (SHG Support), Biodiversity Conservation (Tribal Engagement), KERA Project (Smallholder Focus), FPO Programme, Njangalum Krishiyilekku Campaign	-Youth engagement in rice farming is limited. -Tenant farmers and sharecroppers face barriers in accessing scheme benefits. -Landless workers in rice value chains are not adequately covered by existing support programmes.

The analysis of current schemes reveals that while multiple interventions target various dimensions of sustainable rice development—ranging from ecological conservation to digital transformation—several systemic challenges remain. Fragmented implementation, limited farmer reach, and gaps in mechanization for smallholders hinder the full potential of these programs. Moreover, climate resilience efforts are regionally restricted, and crop insurance mechanisms often fail to address partial losses. Addressing these constraints requires improved inter-departmental coordination, farmer-centric policy refinement, and a shift towards more inclusive, adaptive, and technology-enabled models to ensure long-term sustainability of rice cultivation.

2.7. SCHEME AVAILABILITY IN CLIMATE-RESILIENT AND CONVENTIONAL PADASEKHARA SAMITHIS: DISTRICT-WISE OVERVIEW

This section provides a district-wise summary of the government schemes availed by farmers in both Climate-Resilient Padasekhara Samithis and Conventional Padasekhara Samithis during the Puncha cropping season (2024-25). The objective is to document the actual scheme facilitation at the community level, reflecting the broader policy support mechanisms accessible to paddy farmers across different regions and cultivation systems.

2.7.1. Alappuzha

Table 2.2. Government schemes availed by farmers in Alappuzha

Scheme/Subsidy	Provision in climate resilient samithi	% of farmers availed in climate resilient samithi	Provision in conventional samithi	% of farmers availed in conventional samithi
Seed subsidy	Full subsidy for 40 kg/acre	83	Full subsidy for 40 kg/acre	100
Lime subsidy	Rs. 100 subsidy on each 10 kg pack	50	Rs. 100 subsidy on each 10 kg pack	33
Pumping subsidy	Rs. 2500/acre	100	Rs. 2500/acre	100
Samithi office charge	Nil		Rs. 5000/year-support provided to the samithi	
State crop insurance	Enrolled	83	Enrolled	17
Restructured weather based crop insurance	Enrolled	17	Enrolled	33

In Alappuzha, the scheme coverage reflects a comprehensive support package, particularly for input subsidies and risk mitigation. A significant majority of farmers in the Climate-Resilient Samithis (83%) availed full seed subsidy at 40 kg per acre, while lime application support was accessed by 50% of farmers. The pumping subsidy, crucial for water management in below-sea-level farming systems, reached full coverage with 100% uptake. Both the State Crop Insurance and the Restructured Weather-Based Crop Insurance saw moderate to low participation, at 83% and 17% respectively, indicating a gap in complete risk coverage despite scheme availability. In the conventional Samithis, although seed subsidy utilization was universal, lime subsidy coverage was lower at 33%. Both samithi types received equal access to the pumping subsidy, while administrative support in the form of a Samithi office charge was provided only in conventional samithis. Crop insurance uptake in conventional areas was notably lower, particularly for the state scheme (17%), suggesting possible gaps in awareness or enrolment procedures.

2.7.2. Palakkad

Table 2.3. Government schemes availed by farmers in Palakkad

Scheme/Subsidy	Provision in climate resilient samithi	% of farmers availed in climate resilient samithi	Provision in conventional samithi	% of farmers availed in conventional samithi
Seed subsidy	Nil		Nil	
Lime subsidy	Rs. 100 subsidy on each 10 kg pack	40	Rs. 100 subsidy on each 10 kg pack	66
Ploughing subsidy	3200/acre	14	Nil	
Samithi office charge	Nil		Nil	
State crop insurance	Enrolled	81	Enrolled	100
Restructured weather based crop insurance	Enrolled	77	Enrolled	83

In Palakkad, the availability of input subsidies was more limited compared to other districts. The seed subsidy was not availed by any farmers during the season, marking a significant gap in input assistance. Lime subsidy support was relatively moderate, with 40% of farmers in Climate-Resilient Samithis and 66% in conventional samithis utilizing the provision. Ploughing subsidies were accessible only to climate-resilient farmers, but uptake remained low at 14%, suggesting possible procedural barriers. Insurance participation was comparatively higher: 81% of climate-resilient farmers and 100% of conventional farmers enrolled in the State Crop Insurance Scheme, while participation in the Restructured Weather-Based Crop Insurance stood at 77% and 83%, respectively. These figures indicate that while farmers are increasingly recognizing the importance of risk mitigation, there are substantial gaps in input assistance, particularly in seed distribution and mechanization-related support.

2.7.3. Thrissur

Table 2.4 Government schemes availed by farmers in Thrissur

Scheme/Subsidy	Provision in climate resilient samithi	% of farmers availed in climate resilient samithi	Provision in conventional samithi	% of farmers availed in conventional samithi
Seed subsidy	Nil		50 % subsidy for 40 kg/acre	100
Lime subsidy	Rs. 100 subsidy on each 10 kg pack	100	Rs. 100 subsidy on each 10 kg pack	100
Ploughing subsidy	Rs. 3000/acre	22	Rs. 3000/acre	17
Samithi office charge	Nil		Nil	
State crop insurance	Enrolled	100	Enrolled	100
Restructured weather based crop insurance	Enrolled	44	Enrolled	50

Thrissur exhibited high participation in input subsidy schemes, particularly for lime application, where 100% of farmers across both samithi categories availed the support. The seed subsidy uptake showed divergence, with only conventional farmers benefiting from a 50% subsidy at 40 kg per acre, while the climate-resilient samithi did not receive seed support during the season. The ploughing subsidy, though available to both groups, was availed by a small proportion of farmers—22% in climate-resilient and 17% in conventional samithis—indicating possible barriers related to machinery availability or service access. Insurance participation was robust in the district, with 100% enrollment in the State Crop Insurance Scheme, but participation in the Restructured Weather-Based Crop Insurance was lower (44% and 50% in climate-resilient and conventional samithis, respectively). These patterns suggest that while basic input support and crop protection mechanisms are functioning well, there remains scope to improve coverage for mechanization subsidies and strengthen enrollment in supplementary insurance schemes.

2.7.4. Kottayam

Table 2.5. Government schemes availed by farmers in Kottayam

Scheme/Subsidy	Provision in climate resilient samithi	% of farmers availed in climate resilient samithi	Provision in conventional samithi	% of farmers availed in conventional samithi
Seed subsidy	Nil		75% subsidy	100
Lime subsidy	Rs. 100 subsidy on each 10 kg pack	33	Rs. 100 subsidy on each 10 kg pack	66
Pumping subsidy	Rs. 1800/acre	66	Rs. 1900/acre	100
Ploughing subsidy	Rs. 2800/acre	33	Nil	
Samithi office charge	Nil		Nil	
State crop insurance	Enrolled	33	Enrolled	33
Restructured weather based crop insurance	Nil		Nil	

In Kottayam, scheme utilization presented a mixed scenario. While conventional farmers accessed a 75% seed subsidy with full participation, no seed support was extended to climate-resilient samithis. Lime subsidy uptake was relatively low, with only 33% of climate-resilient farmers and 66% of conventional farmers availing the benefit, pointing to possible supply chain or awareness issues. Pumping subsidies were accessed by 66% of farmers in climate-resilient samithis and by all farmers in conventional samithis, reflecting variation in irrigation needs or access. Ploughing subsidies were again limited, with only 33% uptake in the climate-resilient group and no availing in the conventional samithis. Participation in both crop insurance schemes remained low at 33% for the state scheme, while no farmers enrolled in the weather-based crop insurance across either samithi type. These figures highlight a need to improve insurance enrolment drives and expand support for input assistance and mechanization services to ensure more equitable access.

Table 2.6. Percentage of farmers availed Government schemes across all project area

Scheme/subsidy	Farmers availed (%)
Seed subsidy	37
Lime subsidy	52
Pumping subsidy	32
Ploughing subsidy	11
Samithi office charge	14
State crop insurance	74
Restructured weather based crop insurance	48

The overall scheme uptake across all project sites reveals varied levels of farmer participation in different subsidy and support components. State crop insurance showed the highest coverage, with 74% of farmers enrolled, indicating relatively strong awareness and perceived utility. Lime subsidy was availed by 52% of farmers, reflecting its widespread use in managing soil acidity. Seed subsidy reached 37% of farmers, suggesting moderate uptake, while pumping and ploughing subsidies were significantly lower at 32% and 11%, respectively—pointing to potential barriers in access or operational limitations. Only 14% of farmers benefited from Samithi office charge support, and 48% enrolled in the restructured weather-based crop insurance, indicating a need to strengthen outreach and simplify processes for climate risk coverage. Overall, the data underscores the need for improved awareness, streamlined implementation, and more inclusive targeting to enhance the effectiveness of support schemes for sustainable rice cultivation.

2.8. CONCLUSION

The suite of government schemes and projects supporting paddy cultivation in Kerala represents a robust and multi-dimensional policy framework aimed at promoting ecological sustainability, economic viability, and climate resilience. Initiatives such as the Rice Development Scheme, Operation Double Kole, KERA, and centrally supported programmes like NICRA and PMFBY have provided critical support through input subsidies, mechanization, crop insurance, and adaptive farming strategies. Institutional structures like Padasekhara Samithis, FPOs, and community-based extension systems have been integral to this delivery mechanism.

However, a district-wise review of scheme facilitation reveals operational challenges that continue to limit their transformative potential. Scheme uptake remains uneven across regions and samithi types, with variations in farmer participation in seed subsidies, lime distribution, ploughing and pumping assistance, and crop insurance enrollment. Smallholder constraints, logistical barriers, and procedural complexities often reduce accessibility, especially for vulnerable groups such as tenant farmers and women farmers. The persistence of fragmented implementation, limited scheme convergence, and inconsistent digital integration further exacerbates these gaps.

Against this backdrop, the present project does not seek to duplicate existing efforts but to complement and strengthen them by addressing their limitations. By formulating and field-testing a climate-resilient rice cultivation protocol that is both scientifically validated and farmer-driven, the project aims to bridge policy intent with on-ground realities. Through participatory engagement, continuous monitoring, and region-specific adaptations, this initiative aspires to provide a scalable and inclusive model for resilient rice farming in Kerala—one that aligns with broader sustainability goals while ensuring practical relevance for diverse farming communities.

2.9. SUMMARY

- Kerala's current schemes and policies for sustainable rice cultivation reflect a comprehensive approach that integrates ecological conservation, climate resilience, and farmer support, but their impact is limited by fragmented implementation, low awareness, and uneven access across regions and farming groups.
- Across all project sites, scheme uptake varied considerably—state crop insurance had the highest participation (74%), followed by lime subsidy (52%) and restructured weather-based crop insurance (48%). Seed subsidy reached 37% of farmers, while uptake remained low for pumping subsidy (32%), Samithi office charge support (14%), and ploughing subsidy (11%).
- In Alappuzha, seed subsidy uptake was high in

both samithis (Climate-resilient: 83%, Conventional: 100%), and pumping subsidy reached full coverage (100% in both). However, weather-based crop insurance remained low (Climate-resilient: 17%, Conventional: 33%).

- In Palakkad, state crop insurance had strong participation (Climate-resilient: 81%, Conventional: 100%), but seed subsidy was completely absent (0% in both), and ploughing subsidy uptake was very low (Climate-resilient: 14%).
- In Thrissur, lime subsidy saw full uptake (100% in both samithi types), but seed subsidy was denied to climate-resilient samithis (0%), while conventional samithis accessed it fully (100% at 50% subsidy). Ploughing subsidy remained modest (Climate-resilient: 22%, Conventional: 17%).
- In Kottayam, conventional samithis received 75% seed subsidy with 100% uptake, whereas climate-resilient samithis received none (0%). Pumping subsidy varied (Climate-resilient: 66%, Conventional: 100%), and crop insurance enrollment was low across both (State insurance: 33%, Weather-based: 0%).
- Crop insurance needs urgent reform to become more geographically adaptive, including district-specific risk models, partial loss compensation, and simplified enrollment.
- Digital agriculture services are expanding, but infrastructure gaps and low digital literacy limit reach; targeted capacity-building is required.
- The scheme uptake scenario in Kerala reveals stark regional and institutional disparities. While some inputs like lime and pumping subsidies achieved high coverage in specific districts, access to seed subsidies, ploughing assistance, and insurance schemes remains inconsistent.

These findings highlight the need for more equitable distribution, improved outreach, and convergence in scheme delivery to ensure uniform support for sustainable rice farming across all districts.

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CHAPTER 3
Stakeholder Survey, Prioritization of Key Challenges, and Development of Climate-Resilient Protocol

3.1. INTRODUCTION

Developing a climate-resilient rice farming protocol requires a comprehensive understanding of the successful practices currently adopted by farmers, as well as validation from agricultural experts. To achieve this, a detailed stakeholder survey was conducted across the four major rice-growing districts of Kerala—Kottayam, Alappuzha, Palakkad, and Thrissur. These regions were selected due to their distinct agro-ecological conditions, including below-sea-level farming systems, Kole wetlands, and conventional paddy fields, ensuring a representative sample of Kerala's rice cultivation landscape.

The survey primarily targeted active and successful rice farmers who have consistently managed to sustain or improve yields despite climatic stresses and resource limitations. The objective was to document the best on-field practices, including climate adaptation techniques, resource conservation strategies, varietal preferences, pest and disease management methods, and innovative post-harvest approaches. In addition to farmer consultations, the survey team also engaged with agriculture officials, Krishi Bhavan staff, Padasekhara Samithi leaders, and field-level extension personnel. These interactions were essential not only for identifying recommended practices but also for obtaining expert feedback to ensure that the proposed protocol aligns with scientific standards, government guidelines, and ground realities.

3.2. METHODOLOGY

The project adopted a systematic, multi-phased approach to develop and evaluate a climate-resilient paddy cultivation protocol tailored to the diverse agro-ecological conditions of Kerala. The methodology encompassed stakeholder identification, regional profiling, farmer consultations, scientific validation, participatory implementation, and post-harvest evaluation. The process was designed to ensure practical relevance, scientific rigor, and continuous feedback from the field.

3.2.1 Study Area Selection and District Profiling

Four major paddy-growing districts—Palakkad, Alappuzha, Thrissur, and Kottayam—were selected based on their significant share in Kerala's rice production, ecological diversity, and varying degrees of climate vulnerability. Together, these districts represent a broad spectrum of rice ecosystems, from low-lying Kuttanad wetlands to canal-irrigated plains and midland terrains.

A detailed district-level profiling was undertaken using government databases, agricultural census records, and expert consultations. Key demographic and agronomic indicators—such as population distribution, rural–urban ratios, and area under high-yielding paddy varieties—were analyzed to contextualize the selection of locations and identify potential challenges in each region.

Table 3.1. District-wise demographic and paddy cultivation Data

No	District	Total Population	Sex Ratio	Population Density	Rural Population	Urban Population	Area under HY Paddy (Ha)
1	Palakkad	28,10,892	1067	627	21,33,699	6,77,193	76,371.93
2	Thrissur	31,10,327	1109	1026	10,20,537	20,89,790	23,845.63
3	Kottayam	19,79,384	1040	896	14,13,773	5,65,611	19,688.38
4	Alappuzha	21,21,943	1100	1501	9,74,916	11,47,027	40,000.68
	Kerala	**3,33,87,677**	**1084**	**859**	**1,74,55,506**	**1,59,32,171**	**1,98,450.27**

Source: Census data, 2011. * Including dry paddy. Source: Agricultural statistics, 2023

Based on this profiling, specific locations within each district were identified, taking into account the extent of paddy cultivation, agro-climatic suitability, and logistical feasibility for monitoring and implementation.

3.2.2 Identification of Successful Farmers and Baseline Interactions

With support from Principal Agricultural Officers and local Agricultural Officers, the project team established contact with key farming communities in the selected regions. Emphasis was placed on identifying progressive and experienced paddy farmers who had successfully adopted innovative or adaptive practices in response to climate variability.

Interviews with a structured questionnaire (Appendix II) were conducted with these farmers to document ground-level perspectives on cultivation patterns, input usage, climate-induced stresses (such as unseasonal rainfall, drought, or pest outbreaks), and traditional or emerging mitigation strategies. The insights gained during these baseline interactions were critical in designing a practical and region-specific climate-resilient cultivation protocol.

3.2.3 Development and Validation of Climate-Resilient Protocol

Based on the inputs of the identified successful farmers, a climate-resilient paddy farming protocol was developed for each project district. The protocol integrated traditional farmer wisdom with technological interventions and was refined and validated through expert consultations with agricultural experts.

3.3. RESULTS AND DISCUSSION

3.3.1. Stakeholders Surveyed and Categorisation of Challenges

Through a survey of 171 paddy farmers (among 171 farmers, 69 farmers were surveyed in post harvest survey) across the districts of Palakkad, Thrissur, Alappuzha, and Kottayam.

Table 3.2. Data on stakeholders surveyed (n=186)

	KOTTAYAM	ALAPPUZHA	THRISSUR	PALAKKAD
Total No. surveyed	41	31	41	73
Farmers	27	20	26	64
Lease farmers	10	7	12	5
Agri.officers	2	1	2	4
Agri. Assistants	2	3	1	0
Others (specify)	0	0	0	0

A total of 36 challenges were identified, which are categorized into six distinct groups. The first category encompasses seven climate change issues, including untimely and irregular rainfall, excess rainfall, flooding, water scarcity, cloaked cloudy skies and high ambient temperatures. These factors significantly disrupt the agricultural calendar and negatively affect crop yields. Additionally, we identified seven impacts of weather changes, such as delay in sowing time, destruction of bunds due to floods, chaffing from heat stress, blight infestations resulting from excess rain, and increased pest and disease issues, weed infestation, leaf eating caterpillar infestation due to cloaked cloudy sky, all of which further complicate farmers' challenges.

Cost-related challenges form another critical category, with nine identified issues including high costs for fertilizers, pesticides, weedicides, seeds, irrigation infrastructure, weeding labour and over all labour. The overall increase in harvesting and post-harvest costs places additional financial strain on farmers. Moreover, we observed six shortages impacting rice cultivation such as lack of good quality seeds, irrigation water, infrastructure, functional machinery, and skilled labor, along with a general labor shortage.

Other challenges include increased soil acidity, saltwater intrusion, crop damage from wildlife, delays in payments from Supplyco, and delay in seed procurement by authorities. Finally, two insurance and subsidy-related challenges were noted: difficulties in obtaining insurance payouts due to lapses in rules and delayed subsidy disbursements that hinder financial stability for farmers.

Table 3.3. Prioritized list of challenges identified by farmers

Category	Major challenges	Code
Climate change issues	Untimely rainfall	1
	Irregular rainfall	2
	Excess rainfall	3
	Flood	4
	Water scarcity	5
	Cloaked cloudy sky	6
	High ambient temperature	7
Impacts of weather change	Delay in sowing time	8
	Destruction of bund due to flood	9
	Chaffing due to heat stress	10
	Blight infestation due to excess rain	11
	Pest and disease infestation	12
	Weed infestation	13
	Leaf eating caterpillar infestation due to cloaked cloudy sky	14
Cost hike	High fertilizer cost	15
	High pesticide cost	16
	High weedicide cost	17
	High seed cost	18
	High labour cost-overall	19
	High weed removal labour cost	20
	High irrigation infrastructure cost	21
	High harvesting cost	22
	High post-harvest cost	23

Shortages	Lack of good quality seed	24
	Lack of good quality irrigation water	25
	Lack of irrigation infrastructure	26
	Lack of functional machines	27
	Lack of skilled labour	28
	Labour shortage	29
Other	Increased soil acidity	30
	Salt water intrusion	31
	Crop damage due to wildlife attack	32
	Delay in getting payment from Supplyco	33
	Delay in procuring seeds by seed authority	34
Insurance rules & subsidy	Unable to obtain insurance money (due to lapses in rules)	35
	Delayed subsidy disbursement	36

Table 3.4 Categories of challenges identified

Code	Category
1-7	Climate change issues
8-14	Impacts of weather change
15-23	Cost hike
24-29	Shortages
30-34	Other
35-36	Insurance rules & subsidy

3.3.2. Major Challenges of Paddy Farming in Kerala

According to the surveyed farmers in Kerala, climate change issues and the subsequent impacts of weather change are the major challenges faced by the paddy farming community (48%). Additionally, 10% of farmers cited cost hikes as a significant challenge, while 5% identified shortages as an issue affecting their operations.

Table 3.5. Major challenges faced by farmers in Kerala

Sl No	Challenges	Percentage	Rank
1	Climate change issues and the subsequent impacts of weather change	48	1
2	Cost hike	10	2
3	Shortage	5	3

A consolidated analysis of farmer responses reveals that 48% of farmers identified climate change and its associated weather-related impacts as the most significant challenge affecting paddy cultivation. Among these, blight infestation caused by excess rainfall, affecting 14% of respondents, emerged as the most pressing concern. Prolonged moisture conditions create an environment highly conducive to pathogen proliferation, leading to substantial yield losses, deterioration in grain quality, and reduced marketability. Flooding, reported by 8% of farmers, was the second-most critical challenge, with severe consequences such as field submergence, crop destruction, and soil erosion—disrupting both immediate productivity and long-term soil health. Additionally, irregular rainfall patterns, high ambient temperatures, and untimely rainfall, each cited by 7% of respondents, further complicate water management by creating conditions of either water scarcity or prolonged soil wetness, both of which hinder optimal crop development. Pest and disease infestations, though reported by a smaller proportion (2%), are also strongly linked to these climatic fluctuations, underscoring the broader implications of climate variability on crop health and resilience.

In parallel with these climate-induced stresses, cost-related challenges were reported by 10% of farmers, reflecting growing concerns over the economic sustainability of paddy farming. Rising input costs—particularly high fertilizer and seed prices (5%) and high overall labour expenses (4%)—limit farmers' capacity to invest adequately in crop management, often resulting in compromised productivity. A further 5% of respondents reported shortages of key agricultural inputs and services. These included the lack of good quality seed (3%) and labour shortages (2%), both of which adversely affect timely field operations and crop establishment.

These challenges emphasize the complex interplay of environmental factors, economic pressures, and agricultural practices. The predominance of blight infestation and flooding underscores the urgent need for adaptive measures to enhance resilience against climate-related threats. Addressing labor costs, seed quality, and pest management is essential for improving overall productivity and farmer livelihoods. To effectively combat these challenges, strategies such as investing in research for disease-resistant rice varieties, implementing better water management practices, providing training on sustainable practices, exploring financial support for rising input costs, and encouraging community-based approaches to improve seed distribution and labor availability are recommended. By adopting these strategies, the resilience of paddy farmers in Kerala can be significantly enhanced, ensuring sustainable rice production and supporting the livelihoods of those dependent on this vital crop.

3.3.3. District Wise Analysis of Challenges of Paddy Farming

The ranking of major challenges has also been conducted on a district-wise basis, considering the variations in geographic features, agro climatic conditions, and socio-economic aspects across the study districts.

3.3.3.1. Alappuzha

Table 3.6. Major challenges faced by farmers in Alappuzha

SI No	Challenges	Percentage (%)	Rank
1	Flood	33	1
2	Irregular rainfall	30	2
3	Untimely rainfall	26	3
4	High ambient temperature	19	4
5	Delay in getting payment from Supplyco	11	5
6	Delay in sowing time	4	6
7	Destruction of bund due to flood	4	6
8	Weed infestation	4	6
9	High fertilizer cost	4	6
10	Lack of good quality seed	4	6
11	Salt water intrusion	4	6

Paddy cultivation in Alappuzha district is marked by a high degree of vulnerability to climatic and systemic stresses, as reflected in the challenge rankings reported by farmers. The most critical issue identified is flooding, cited by 33% of respondents. Given the low-lying nature of much of Alappuzha's paddy land, particularly in the Kuttanad region, fields are highly prone to seasonal inundation. Flooding not only damages standing crops but also causes erosion of bunds, delays in post-flood field operations, and prolonged waterlogging that restricts replanting or timely land preparation.

Closely related to this is the issue of irregular rainfall, reported by 30% of farmers. The unpredictability of rainfall patterns disrupts key agricultural operations such as sowing, transplanting, and fertilization schedules. This is compounded by untimely rainfall, which affects 26% of respondents and often leads to crop lodging, nutrient leaching, and heightened disease incidence—particularly during flowering and harvesting stages. High ambient temperatures, cited by 19% of farmers, further exacerbate water stress and reduce the physiological efficiency of rice crops. Together, these climate-related factors highlight the significant exposure of Alappuzha's paddy ecosystem to changing weather patterns.

Beyond climatic challenges, institutional and operational issues also impact the sustainability of rice farming in the district. A notable concern is the delay in receiving payments from Supplyco, reported by 11% of farmers. Such delays undermine farmer confidence in the procurement system and restrict cash flow during critical input-purchasing periods. Delay in sowing time (4%) and destruction of bunds due to flood (4%) are additional operational challenges that contribute to inconsistent yields and increased vulnerability to pest and weed pressure.

Input-related issues also persist. Weed infestation (4%) and high fertilizer costs (4%) reflect a combination of field-level management difficulties and rising input expenses. Furthermore, lack of access to good quality seed, reported by 4% of farmers, poses a threat to crop establishment and yield stability. Salt water intrusion—though reported by a smaller proportion (4%)—is an emerging concern in coastal and brackish water-influenced areas, with long-term implications for soil health and crop viability. In summary, the challenges in Alappuzha represent a complex mix of climatic volatility, infrastructural gaps, economic uncertainties, and agronomic limitations.

3.3.3.2. Thrissur

Table 3.7. Major challenges faced by farmers in Thrissur |

Sl No	Challenges	Percentage	Rank
1	High ambient temperature	18	1
2	Untimely rainfall	13	2
3	Lack of good quality seed	13	2
4	Pest and disease infestation	11	3
5	Weed infestation	11	3
6	Labour shortage	11	3
7	Irregular rainfall	5	4
8	Chaffing due to heat stress	5	4
9	High labour cost-overall	3	5
10	Lack of irrigation infrastructure	3	5
11	Unable to obtain insurance money (due to lapses in rules)	3	5
12	Delay in getting payment from Supplyco	3	5

Paddy farmers in Thrissur district face a combination of climatic, agronomic, and systemic challenges that affect the sustainability and productivity of rice cultivation. The most frequently reported issue is high ambient temperature, cited by 18% of respondents. Prolonged exposure to elevated temperatures during critical growth stages contributes to physiological stress in plants, reduced grain filling, and increased risk of chaffing.

Untimely rainfall and lack of good quality seed were each reported by 13% of farmers. Rainfall occurring outside key crop stages often disrupts sowing and harvesting operations, while poor seed quality directly undermines germination, crop uniformity, and yield potential. The dual occurrence of these challenges highlights the sensitivity of the district's paddy cultivation to both climatic anomalies and input reliability.

Pest and disease infestations, along with weed infestation and labour shortage, were each cited by 11% of farmers, suggesting a high burden of biological stressors and operational constraints. These issues not only demand timely intervention and increased input use but also place additional pressure on labour resources, which are already limited. The combined effect results in higher production costs and lower efficiency in field operations.

Irregular rainfall (5%) and chaffing due to heat stress (5%) further underline the district's exposure to climate variability, affecting both crop health and grain quality. High overall labour cost, lack of irrigation infrastructure, inability to obtain insurance payouts due to procedural lapses, and delay in receiving payments from Supplyco were each reported by 3% of respondents. These systemic and financial issues erode farmer confidence, limit their risk-taking capacity, and restrict reinvestment in farming activities. In summary, the challenges reported by Thrissur farmers reflect a multidimensional stress environment, shaped by rising temperatures, erratic rainfall, seed and labour limitations, pest pressure, and gaps in institutional support mechanisms.

3.3.3.3. Palakkad

Table 3.8. Major challenges faced by farmers in Palakkad

Sl No	Challenges	Percentage	Rank
1	Blight infestation due to excess rainfall	35	1
2	High labour cost-overall	12	2
3	Irregular rainfall	7	3
5	High ambient temperature	6	4
6	Untimely rainfall	6	4
7	Pest and disease infestation	3	5
8	Flood	1	6
9	Delay in sowing time	1	6
10	Weed infestation	1	6
11	High fertilizer cost	1	6
12	Chaffing due to heat stress	1	6
13	Crop damage due to wildlife attack	1	6

Paddy cultivation in Palakkad, one of Kerala's most prominent rice-producing districts, is facing significant agronomic and climatic challenges, with blight infestation due to excess rainfall emerging as the most severe concern. This issue was reported by 35% of farmers—the highest among all recorded challenges—highlighting the widespread impact of prolonged wet conditions during critical crop stages. Excess moisture not only facilitates the rapid spread of pathogens but also weakens plant defences, resulting in severe yield and quality losses.

The second most reported constraint is high overall labour cost, cited by 12% of respondents. With increasing dependency on hired labour and limited mechanization in many parts of the district, production expenses have risen substantially, eroding farmer profitability.

Irregular rainfall (7%), high ambient temperature (6%), and untimely rainfall (6%) reflect the growing unpredictability in local weather patterns. These climatic inconsistencies affect sowing schedules, crop development, and water management, and also exacerbate biotic stress. Pest and disease infestations, reported by 3%, remain a persistent threat and are likely intensified by fluctuating weather and excess humidity.

A series of other challenges—each reported by 1% of farmers—include flooding, delay in sowing, weed infestation, high fertilizer cost, chaffing due to heat stress, and crop damage due to wildlife attack. While these appear less widespread, they are still significant at the local level and indicate the diverse stress profile farmers face in different pockets of the district. Overall, the data from Palakkad reveal that farmers are operating in an increasingly climate-sensitive production environment, with weather-induced disease outbreaks, rising labour costs, and erratic rainfall patterns forming the core of their production constraints.

3.3.3.4. Kottayam

Table 3.9. Major challenges faced by farmers in Kottayam

Sl No	Challenges	Percentage	Rank
1	High fertilizer cost	22	1
2	High labour cost-overall	19	2
3	Untimely rainfall	19	2
4	Flood	14	3
5	Weed infestation	11	4
6	Lack of good quality seed	8	5
7	High ambient temperature	8	5
8	High post-harvest cost	5	6
9	Lack of irrigation infrastructure	5	6
10	Chaffing due to heat stress	5	6
11	Blight infestation due to excess rainfall	5	6
12	Labour shortage	3	7
13	Irregular rainfall	3	7
14	Pest and disease infestation	3	7
15	Destruction of bund due to flood	3	7

Paddy farmers in Kottayam district are confronted with a complex blend of economic, climatic, and infrastructural challenges that collectively hinder the sustainability and profitability of rice cultivation. Notably, the most frequently reported issue was high fertilizer cost, cited by 22% of respondents. This reflects the mounting financial pressure on farmers, especially in the context of rising input prices, which limit their capacity to invest adequately in crop management.

Closely following this are high overall labour costs and untimely rainfall, each reported by 19% of farmers. Labour costs in Kottayam remain high due to limited availability of skilled workers and the continued reliance on manual operations. At the same time, untimely rainfall has disrupted critical farming stages, particularly transplanting and harvesting, thereby increasing vulnerability to yield loss.

Flooding, reported by 14% of farmers, remains a persistent seasonal challenge, especially in low-lying paddy fields, causing submergence and damage to standing crops. Weed infestation (11%) was also widely reported, suggesting gaps in timely weed management practices and the need for effective integrated weed control strategies.

Several resource and infrastructure-related shortages further compound the difficulties faced by farmers. Lack of good quality seed and high ambient temperature were each reported by 8%, while high post-harvest costs, lack of irrigation infrastructure, chaffing due to heat stress, and blight infestation due to excess rainfall were each cited by 5% of respondents. These challenges reflect both environmental stressors and systemic gaps in post-harvest and irrigation support services.

Lower-ranked but still significant challenges include labour shortage, irregular rainfall, pest and disease infestation, and destruction of bunds due to floods, each reported by 3% of farmers. While less frequently mentioned, these issues indicate localized vulnerabilities that can become severe under specific field or climatic conditions. In summary, paddy cultivation in Kottayam is heavily influenced by the rising cost of inputs, labour market constraints, and increasing climate variability.

3.3.4. Climate Resilient Farming Protocol

During our stakeholder survey, we engaged with over 100 successful rice farmers, each with more than 50 years of farming experience. The data collected reflects their extensive expertise. We identified the best farming practices based on scientific validity, environmental compliance, and cost-effectiveness, focusing on the following criteria:

1. Cost-effectiveness
2. Reduced toxicity—minimizing harmful substances
3. Decreased chemical usage
4. Consideration of geographical features
5. High yield potential
6. Lower costs for weeding and labor
7. Maximization of effective mechanization
8. Sustainability

Based on these criteria, we developed a comprehensive protocol and consulted experts from the Krishi Vigyan Kendra (KVK) and Kerala Agricultural University. Their insights guided us in determining the methodologies for each stage of rice cultivation. We have developed separate protocols for both broadcasted and transplanted rice cultivation.

While the protocol cannot prevent climatic events such as untimely rainfall or drought, it is specifically designed to address the indirect impacts of climate change on rice cultivation. These include challenges like poor seedling establishment, increased pest and disease pressure, delayed harvests, and yield fluctuations. By focusing on field-level adaptations and preventive strategies, the protocol enables farmers to reduce the vulnerability of their crops to such climate-induced disruptions.

The table below outlines key weather change events, their direct effects, and the indirect impacts that pose both economic and ecological challenges to rice farmers in Kerala:

Table 3.10. Weather change events and impacts

Weather Change events	Direct Impacts	Indirect Impacts
Untimely rainfall	• Delays sowing and transplanting • Affects seedling establishment • Promotes early weed emergence and competition • Pest and disease outbreak • Causes poor field drainage during harvest, hindering harvest operations	• Replanting costs • Additional weeding cost • Additional cost for plant protection • Increased time and cost for harvesting due to waterlogged field conditions • Risk of grain germination in the field
Irregular rainfall	• Inconsistent soil moisture • Disturbs critical growth stages • Increases pest, disease and weed pressure	• Higher costs for irrigation, weed management and plant protection • Reduced yield
Excess rainfall	• Causes flooding • Promotes root damage • Favors pest, disease and weed infestation	• Crop loss due to poor plant health • Higher cost of pest, disease and weed management
Flood	• Submerges entire fields • Destroys crop stands • Destroys irrigation infrastructure • Alters soil structure and fertility • Chemically farmed rice plants may deteriorate more rapidly under prolonged wet conditions	• Crop failure • Repair cost for irrigation infrastructure • Yield loss due to plant decay and poor grain recovery

Cloaked cloudy sky	• Creates optimal microclimatic conditions that promote the onset and proliferation of pest insect and pathogen life cycles • Delays crop maturity • Poor grain quality	• High pest and disease management cost • Harvest delays increase labor costs
Hydrological drought	• Reduces tillering, flowering, and grain filling • Leads to stunted growth • Delays maturity	• Extra cost for water access • Reduced yield lowers total income
High ambient temperature	• Increases evapotranspiration and water stress • Reduces flowering and pollination • Causes chaffing of grains	• Irrigation demand and energy costs increase • Lower grain weight
Salt water intrusion	• Increases soil salinity, affecting nutrient uptake • Reduces tillering and grain filling • Causes physiological stress in rice plants	• Yield reduction due to poor crop establishment and growth

The stagewise protocol set in the pattern of POP is given below: The Malayalam version of the protocol (Appendix IV) printed and distributed among the selected farming communities.

3.3.4.1 Farming Protocol Proposed for Broadcasting

Fig 3.1. Sowing using seed drum in Alappuzha

3.3.4.1. Protocol for broadcasted rice

Sl No	Stage	Proposed practice	Remarks
1	Land preparation	Land preparation Perform soil test	Conducting a soil test provides valuable insights into nutrient levels, and pH, allowing for tailored soil management and fertilizer applications that enhance crop health and productivity while also reducing costs.
		Plough the field twice using a tractor with gauge wheels attached. For the first round, go straight in rows, and for the second round, go across in columns. Then, level the field using a helical puddler mounted on the tractor.	Ploughing the field twice, first in rows and then in columns, ensures thorough soil aeration and effective mixing of topsoil, which promotes better seedbed preparation. This cross-ploughing technique helps to break up compacted soil layers and improve drainage. Following this with leveling using a helical puddler ensures an even surface, which enhances water distribution and reduces erosion. Together, these practices improve soil health, optimize crop yields, and facilitate easier management of the field.
		Stale seedbed technique After land preparation, leave the field for 2 weeks for weed seed germination. Destroy the germinated seedlings by ploughing the field or by spraying non selective herbicides glufosinate ammonium @ 8 ml product/litre of water. 4-5 days after herbicide application, let in water and flood the field to allow complete kill of the emerged seedlings. Drain the field after 10 days of flooding. Sow the germinated rice seed the next day.	By allowing weed seeds to germinate and then destroying the seedlings, can reduce the weed seed bank and improve crop establishment conditions. Using a non-selective herbicide like glufosinate ammonium ensures thorough elimination of unwanted plants, while flooding creates an anaerobic environment that further suppresses weeds. Draining the field before sowing allows for optimal seedbed conditions, enhancing rice germination and establishment.

		Dolomite application 140 kg dolomite or 100 kg lime is applied after the first round of ploughing. Keep it for 4 days before washing it off. A second application is required one month after sowing at the rate of 100 kg per acre	Applying dolomite or lime improves soil pH and enhances nutrient availability, which is crucial for healthy crop growth. The initial application after the first ploughing helps to neutralize soil acidity, promoting better microbial activity and improving the soil structure. Allowing it to sit for a few days helps the amendments to integrate into the soil. The subsequent application one month after sowing provides a continued source of essential nutrients, particularly calcium and magnesium, which support plant development.
		Companion Planting: Plant marigold or chrysanthemum at the time of sowing, along the bunds to repel pests such as stem borer.	Planting marigold or chrysanthemum along the bunds acts as a natural pest repellent, particularly against pests like stem borer. These flowers release compounds that deter harmful insects while attracting beneficial ones. This practice enhances biodiversity, reduces the need for chemical pesticides, and can lead to healthier crops and improved yields.
		Phosphate application After the second round of ploughing, apply rock phosphate in the necessary amount based on soil test results. If phosphate is in excess in soil, avoid its usage.	Applying rock phosphate after the second round of ploughing improves soil phosphorus levels, which is vital for root development, flowering, and fruiting in crops. Tailoring the application based on soil test results ensures that the right amount is used, preventing over-application and minimizing environmental impact. This practice enhances nutrient availability, promotes healthy plant growth, and can lead to increased crop yields and overall soil fertility.
2	Seed selection	Uma / D1	
	Seed rate	15-20 kg/acre- Drum seeding	Saving of seed quantity
	Seed treatment	Dip the seeds in a salt solution made by dissolving 1.5 kg of salt in 10 liters of water. This method will help separate the half-filled seeds before treatment. After separation, wash the seeds thoroughly with water twice. Then soak the seeds in a solution of 800 g of PGPR 2 mixed with 30 liters of water for 24 hours. After soaking, spread the seeds and cover them for an additional 24 hours to provide warmth and encourage germination.	It's important that the seeds are at the initial stages of germination to prevent tangling in the seed drum. Once they are ready, sow the seeds in the field with 1-2 inches of water.
3	Mode of sowing	Seed drum Benefits of sowing seeds with a seed drum	

		• Uniform Seed Distribution: Ensures even spacing and depth for consistent germination	
		• Lower Seed Rate: Allows for optimal seed usage, reducing overall input costs.	
		• Time Efficiency: Enables quicker field coverage compared to manual methods.	
		• Better Soil Contact: Improves seed-to-soil contact, enhancing germination rates.	
		• Reduced Pest and Disease Incidence: Uniform planting can lower pest and disease pressure due to healthier crop stands.	
		• Weed Suppression: Dense, evenly spaced crops can outcompete weeds, reducing weed growth and the need for herbicides.	
		• Less Harvest Time: Efficient sowing can lead to more synchronized crop maturity, easy movement of harvester, simplifying harvesting.	
4	Watering protocol	0 DAS - Maintain 5 cm water film while sowing 5 DAS- draining the field 15 DAS- after weedicide application irrigating the field 20-22 DAS - draining	
		25 DAS - Watering the field (after 24 hours of first round of fertilizer application) 35 DAS -By the time field almost become dry and water again 40-44 DAS - Again the field becomes dry. Application of fertilizer (2nd round).	
		45 DAS -Watering 55 DAS -Watering 65 DAS - watering 75 DAS -watering 85 DAS -watering 95 DAS -watering 105 DAS -watering No watering further	
5	Weed management	Weedicide application at 15 DAS/ at 2-3 leaved stages of weeds in case of transplanted rice.	

		Mix 1 liter of Vivaya and 14 grams of Affinity in 100 liters of water for controlling broad-leaved weeds and sedges. Apply using a floodjet nozzle.	- Promotes sustainable practices by using specific herbicides in a targeted manner, reducing the need for multiple applications. - Using a floodjet nozzle ensures uniform coverage and better penetration of herbicide over dense weed canopies, enhancing weed control efficiency.
		Drain the field before applying the herbicide. Water the field 48 hours after herbicide application, then drain again and apply the first dose of fertilizer.	- Enhances nutrient availability, as draining before application ensures the herbicide works effectively, and watering afterward aids nutrient absorption. - Improves resource use by applying the herbicide before flooding, minimizing water contamination and optimizing effectiveness.
		KAU Weed Wiper Kerala Agricultural University, for the post-emergence management of weedy rice by direct contact application (DCA) of broad-spectrum non-selective herbicides using specially designed novel hand held weed wiper device could selectively dry the panicles of weedy rice at 55-60 DAS, taking advantage of the height difference of 15-20 cm between weedy rice and cultivated rice. DCA can be effectively done in weedy rice infested cropped fields using non-selective herbicides, viz. glufosinate ammonium, 100ml/L	The use of a handheld weed wiper for direct contact application of non-selective herbicides effectively targets and dries out weedy rice while minimizing harm to cultivated rice due to the height difference. This method promotes efficient weed management, reduces competition for resources, and enhances crop yield without extensive labor or chemical use, leading to more sustainable farming practices.
			During the survey, farmers expressed their opinions that this practice is labor-intensive and that they are facing a shortage of skilled labor. Moreover, those cultivating on leased land tend to prioritize profit, leading them to show little interest in adopting sustainable practices.
6	Fertilizer application	3 rounds of fertilizer application 15 DAS- Urea 15kg + 3 kg neem cake, potash 15kg. 30-35 DAS- Urea 25kg, potash 20kg 55 DAS- Urea 20kg, potash 25kg (Fertilizer application is adjusted based on soil test result)	Applying urea mixed with neem cake provides a dual benefit to crops. The urea supplies a quick-release source of nitrogen, promoting healthy plant growth, while the neem cake acts as a slow-release organic fertilizer, enhancing soil fertility over time. Additionally, neem cake helps suppress soil-borne pests and diseases due to its natural insecticidal properties, improving overall plant health and resilience.

		Sampoorna Micronutrient mix application Spray Sampoorna 20 DAS at the rate of 5 grams per liter of water. Repeat the application at 50 DAS at the rate of 10 grams per liter.	Enhances nutrient availability, ensuring crops receive essential micronutrients for optimal growth and development.
		Use Leaf Color Chart at 20 DAS Utilize a leaf color chart to assess the nitrogen status of plants. By comparing leaf color with the chart, the precise amount of nitrogen fertilizer needed for optimal growth and nutrient balance can be determined.	This practice enhances efficiency in nitrogen fertilizer application and promotes healthier crops.
7	Pest and disease management	Bacterial leaf blight • Application of bleaching powder @ 5 kg ha-1 in the irrigation water 30 DAS is recommended for preventing the spread of bacterial leaf blight	The chlorine in the bleaching powder can reduce harmful pathogens in the water, preventing their spread to the fields.
		• Conduct the ooze test to confirm the presence of bacteria if symptoms are observed. • Spray fresh cow dung extract. Dissolve 20 g of cow dung in one liter of water, let it settle, and then sieve it. Use the supernatant liquid for spraying. • Pseudomonas spray (5gm/L)	
		• Kcycline/ tagmycin (A broad-spectrum chemical bactericide that contains a combination of Streptomycin Sulphate and Tetracycline Hydrochloride) (30g) + nativo (50g) per acre	K-cyclin and Tagmycin target bacterial pathogens, while Nativo provides fungicidal properties, creating a synergistic effect. This combination reduces disease incidence, promotes healthier plants.

		Stem borer, Leaf folder • Trichogramma chilonis and Tricho gramma japonicum are egg parasitoids which effectively control egg mass of leaf roller, stem borer, skippers and cutworms. The parasitoids have to be released 15-30 days after transplantation or 25-30 days after sowing or immediately after noticing moth activity in the field. The release rate is 1 lakh parasitoids/ha of both sizes (5cc ha-1). The release has to be carried out at weekly intervals. The trichocard has to be cut into small pieces (minimum 10 pieces) and released in the main field, 6-8 releases is necessary to control the pest. Precaution : If larval attack is observed in the field, necessary organic/inorganic insecticides have to be used and a gap of 7 days has to be given before next release. The trichocards have to be placed during early morning or late evening hours and should not come in direct contact with sunlight • Cut the strips and attach them to the leaves using a staple • Cover it with disposable cups when it rains	Using Trichocard for pest control effectively introduces beneficial insects that target and reduce pest populations. This biological control method minimizes the need for chemical pesticides, promoting sustainable agriculture while protecting crops and enhancing biodiversity.
		Apply the following insecticides in the field where the symptoms of attack are manifested: Coragen- 30 ml in 100 L water or Fame- 30 ml in 100L water	
		Blast • Nativo (Trifloxystrobin+Tebuconazole) 80g in 200L for 1 acre (Nativo has phytotonic effect)- 600 Rs Bug • Prepare a fish amino acid solution at a rate of 15 ml per liter of water. Spray it around the infested area, starting from the periphery and moving inward to encourage the pests to move toward the center. • Since the occurrence of the bug coincides with the flowering stage, application of the insecticide may be done either before 9 a.m. or after 3 p.m. so that fertilization of the flowers is not adversely affected.	Experts have suggested various management measures for caseworm and armyworm. Case worm • A rope soaked in kerosine is passed over the young crop for dislodging the larval cases from the tillers and then the water is drained for eliminating them.

		Minor pests- Aphid, Leaf louse, thrips • Nimbicidine-3-4 ml in 1 L water Pesticide application Do only when it is highly required If symptoms or infestation appeared in one or two spots in the entire field confine the application at such points alone.	Army worm • Flood the fields for 7–14 days after armyworm larvae hatch to drown them and control their population However on a practical level, these measures can be labor-intensive and not feasible for many farmers.
8	Harvesting	1. Optimal Timing of Harvest Recommend harvesting when 80-85% of the grains are mature, ensuring maximum grain yield and quality. Early harvesting can lead to immature grains, while late harvesting increases the risk of shattering and pest damage.	
		2. Recommended Harvesters Use lightweight combine harvesters that are better suited to Kerala's wetland fields, such as those in Alappuzha. These lightweight harvesters reduce soil compaction, making them ideal for regions where soil structure is a concern. The Kubota DC-70G and Yanmar Combine Harvester are recommended due to their efficiency and adaptability to various field conditions. For added convenience and efficiency, a harvester with a long handle discharge system is preferable. Harvesters equipped with grain tank discharge augers allow the direct transfer of harvested rice into a storage container, minimizing grain spillage and reducing additional labor costs. Such machines are beneficial as they cut down on the time and manual effort needed for transferring grains after harvesting.	
		3. Standardized Price for Harvester Hiring To reduce exploitation by harvester agents, a standardized hiring cost per hour or per acre should be implemented and agreed upon by agricultural cooperatives. These bodies can collaborate with local government authorities to establish a fair rate, ensuring transparency and affordability. The current standard price should be reviewed annually, considering factors like fuel costs, labor wages, and seasonal demand.	

9	Marketing	Direct Farmer Markets: Utilize Krishi Bhavan or local cooperative-run markets to bypass intermediaries. Farmer Producer Organizations (FPOs): Join an FPO to benefit from bulk selling and bargaining. Value Addition: Introduce semi-polished rice or packaged paddy to increase market value and earn higher returns.	
10	Insurance	1. Kerala State Insurance Scheme The Kerala State Crop Insurance Scheme is an initiative by the Government of Kerala aimed at providing financial support to rice farmers in the event of crop failure. The scheme helps farmers manage the risks involved in rice cultivation due to adverse weather conditions, pests, and diseases.	
		1. Objectives • To provide insurance coverage and financial support to farmers in the event of crop failure due to natural calamities, pests, and diseases. • To stabilize farmers' incomes, ensuring their continued involvement in rice farming. • To promote rice cultivation in Kerala by reducing the risks associated with crop failure.	
		2. Coverage The scheme provides comprehensive coverage to farmers for: • Sowing/Planting Failures: Coverage for farmers who are unable to sow or plant due to adverse weather conditions. • Standing Crop Loss: Insurance for crop damage during the growing season due to drought, flood, pest attack, hailstorm, and other risks. • Post-Harvest Losses: Coverage for crop losses due to adverse weather, such as unseasonal rainfall or hailstorm, after harvest. • Localized Calamities: Coverage against localized risks such as hailstorms, flash floods, or landslides.	

		3. Eligibility • Eligible Farmers: All farmers growing rice in the notified areas of Kerala, including: • Loanee Farmers: Farmers who have availed loans from financial institutions are automatically covered under the scheme. • Non-Loanee Farmers: Farmers who do not have crop loans but voluntarily wish to avail of insurance coverage.	
		4. Insurance Premium and Subsidy Premium Rates for Farmers: • Farmers are required to pay a nominal premium, typically 2-3% of the sum insured • The government of Kerala provides a premium subsidy, covering the remaining premium amount beyond what the farmers pay, making the scheme affordable.	
		5. Sum Insured • The sum insured is determined based on the cost of cultivation of rice in Kerala, which is revised annually by the Department of Agriculture.	
		6. Enrollment Process Farmers can enroll through their local Krishi Bhavan, cooperative societies, or banks. Farmers need to submit the following documents for enrollment: • Aadhaar card • Land ownership proof or lease agreement for tenant farmers • Bank account details	
		7. Claim Process • Loss Assessment: Loss assessment is carried out through Crop Cutting Experiments (CCEs), conducted by teams comprising representatives from the Agriculture Department, Revenue Department, and insurance companies. • Claim Settlement: Claims are settled directly into the farmers' bank accounts through Direct Benefit Transfer (DBT)	

		2. Pradhan Mantri Fasal Bima Yojana (PMFBY) The Pradhan Mantri Fasal Bima Yojana (PMFBY) is a government-backed crop insurance scheme aimed at providing financial support to farmers in the event of crop failure. Launched by the Government of India in 2016, PMFBY helps farmers manage the risks involved in agriculture due to adverse weather conditions, pests, and diseases. Here are the key details:	
		1. Objectives • To provide insurance coverage and financial support to farmers in the event of crop failure due to natural calamities, pests, and diseases. • To stabilize farmers' incomes, ensuring their continuous engagement in farming. • To encourage farmers to adopt innovative and modern agricultural practices. • To ensure flow of credit to the agriculture sector.	
		2. Coverage PMFBY provides comprehensive coverage to farmers for: • Prevented Sowing/Planting Risk: Coverage is provided when a farmer is unable to plant the crops due to adverse weather conditions. • Standing Crop Loss: Insurance is provided for crop damage during the growing season due to drought, flood, hailstorm, pest attacks, and other risks. • Post-Harvest Losses: Coverage for crops that suffer damage due to unseasonal rainfall or hailstorms after harvest. • Localized Calamities: Coverage against specific localized risks such as hailstorms, landslides, or floods.	

		3. Eligibility
		
		• Eligible Farmers: All farmers growing notified crops in the notified areas, including:
		  o Loanee Farmers: Those who have taken loans from financial institutions are automatically covered under the scheme.
		  o Non-Loanee Farmers: Those who do not have crop loans but voluntarily wish to avail of insurance coverage.	

		4. Insurance Premium and Subsidy
		
		• Premium Rates for Farmers:
		  o Kharif Crops (Monsoon Season): 2% of the sum insured.
		  o Rabi Crops (Winter Season): 1.5% of the sum insured.
		  o Commercial and Horticultural Crops: 5% of the sum insured.
		
		The government (central and state) provides a significant premium subsidy, which covers the remaining premium amount beyond what the farmers pay. The subsidy helps keep premiums affordable.	

		5. Sum Insured • The sum insured is calculated based on the Scale of Finance (SoF) decided by the District Level Technical Committee (DLTC). It reflects the cost of cultivation for the crop and varies depending on the crop type and location.	

		6. Enrollment Process • Offline: Farmers can enroll through their local Krishi Bhavan, cooperative societies, or banks. • Online: Farmers can register on the PMFBY portal (https://pmfby.gov.in/) or through the National Crop Insurance Portal. Farmers need to submit the following documents for enrollment: • Aadhaar card • Land ownership records or proof of land lease for tenant farmers • Bank account details • Crop sowing certificate (provided by the agricultural office)	
		7. Claim Process • Crop Cutting Experiments (CCEs): The yield of a particular area is assessed using crop-cutting experiments (CCEs) conducted at the end of the crop season. The claim process is triggered when the assessed yield is less than the threshold yield. • Prevented Sowing Claims: Claims are initiated if farmers are unable to sow their crops due to adverse climatic conditions. • Claim Settlement: Claims are settled directly into the farmers' bank accounts through Direct Benefit Transfer (DBT).	
		8. Key Features • Wide Coverage: Covers a variety of crops, including cereals, pulses, oilseeds, and horticultural crops. • Area Approach: The scheme follows an area-based approach, meaning insurance is offered to farmers within a defined geographical region notified for insurance purposes. • Technology Use: PMFBY uses technology for yield estimation (through satellite imaging, remote sensing, drones) and faster claim settlements.	

		3. Restructured Weather Based Crop Insurance Scheme (RWBCIS) The RWBCIS is a crop insurance scheme launched by the Government of India to protect farmers against potential financial losses due to adverse weather conditions affecting their crops. Unlike traditional yield-based insurance, RWBCIS provides compensation based on weather data that can influence crop productivity. Here are the detailed aspects of RWBCIS:	
		1. Objectives • To provide insurance coverage to farmers against weather-related risks, such as unseasonal rainfall, high temperatures, humidity, wind speed, etc. • To stabilize farmers' income by compensating them for financial losses due to adverse weather. • To encourage farmers to adopt climate-resilient agricultural practices.	
		2. Coverage RWBCIS covers weather-related risks that can impact crop growth, development, and productivity. The scheme provides coverage for: • Adverse Weather Conditions: Excess or deficit rainfall, extreme temperatures (heat or cold waves), high relative humidity, and strong winds. • Critical Crop Stages: Weather risks are covered based on different growth stages of the crop, such as germination, flowering, and maturation.	

		3. Eligibility • Eligible Farmers: All farmers growing notified crops in the notified areas are eligible to avail of the scheme. o Loanee Farmers: Farmers who have taken crop loans are automatically enrolled. o Non-Loanee Farmers: Voluntary enrollment is open for non-loanee farmers.	
		4. Premium Charges and Subsidy • Premium Rate: o Farmers pay a premium of 1.5% of the sum insured for food crops and oilseeds. o For commercial and horticultural crops, the premium can go up to 5% of the sum insured. • Government Subsidy: o The central and state governments provide a subsidy on the remaining premium, which can cover 75% to 95% of the total premium. o The subsidy helps make the insurance affordable for small and marginal farmers.	
		5. Sum Insured • The sum insured is determined based on the cost of cultivation per hectare of the crop, and it varies from crop to crop and region to region. • It reflects the average yield and expected value of the crop as per local norms.	

		6. Enrollment Process • Offline: Farmers can apply for the scheme at their local Krishi Bhavan, cooperative societies, or designated commercial banks. • Online: Enrollment is available through the RWBCIS portal or the National Crop Insurance Portal. Farmers need to submit: • Aadhaar card • Land records or proof of land lease • Bank account details • Crop sowing certificate	
		7. Claim Process • Automatic Trigger: Claims are automatically triggered based on weather data collected from designated automatic weather stations (AWS). There is no need for physical inspection or crop-cutting experiments. • Weather Index: The scheme uses a weather index that sets certain thresholds for each weather parameter (e.g., temperature, rainfall). If these thresholds are breached, the insurance payout is triggered. • Payouts: Claims are calculated based on the deviation of actual weather data from the pre-specified index, and payments are directly credited to the farmer's bank account through Direct Benefit Transfer (DBT).	
		8. Key Features • Weather Parameter Coverage: The scheme covers a wide range of weather parameters, including rainfall, temperature, humidity, and wind speed, which are crucial for crop growth. • Index-Based Payouts: RWBCIS uses pre-defined weather parameters as triggers for insurance payouts.	
11	Other	Ensure the construction of proper drainage channels and bunds to manage water flow and prevent flooding in the field.	

Fig 3.2. Machine transplanting in Palakkad

3.3.4.2. Protocol for transplanted rice

Sl No	Stage	Proposed practice	Remark
1	Land preparation	Land preparation Perform soil test	Conducting a soil test provides valuable insights into nutrient levels and pH, allowing for tailored soil management and fertilizer applications that enhance crop health and productivity while also reducing costs.
		Plough the field twice using a tractor with gauge wheels attached. For the first round, go straight in rows, and for the second round, go across in columns. Then, level the field using a helical puddler mounted on the tractor.	Ploughing the field twice, first in rows and then in columns, ensures thorough soil aeration and effective mixing of topsoil, which promotes better seedbed preparation. This cross-ploughing technique helps to break up compacted soil layers and improve drainage. Following this with leveling using a helical puddler ensures an even surface, which enhances water distribution and reduces erosion. Together, these practices improve soil health, optimize crop yields, and facilitate easier management of the field.

		Stale seedbed technique After land preparation, leave the field for 2 weeks for weed seed germination. Destroy the germinated seedlings by ploughing the field or by spraying non selective herbicides glufosinate ammonium @ 8 ml product/litre of water. 4-5 days after herbicide application, let in water and flood the field to allow complete kill of the emerged seedlings. Drain the field after 10 days of flooding. When the water gets drained completely, apply oxyfluorfen (Goal) 3ml/L. Transplant the rice seedling the next day.	By allowing weed seeds to germinate and then destroying the seedlings, can reduce the weed seed bank and improve crop establishment conditions. Using a non-selective herbicide like glufosinate ammonium ensures thorough elimination of unwanted plants, while flooding creates an anaerobic environment that further suppresses weeds. Draining the field before sowing allows for optimal seedbed conditions, enhancing rice germination and establishment.
		Dolomite or lime application 140 kg dolomite or 100 kg lime is applied after the first round of ploughing. Keep it for 4 days before washing it off. A second application is required one month after planting at the rate of 100 kg per acre	Applying dolomite or lime improves soil pH and enhances nutrient availability, which is crucial for healthy crop growth. The initial application after the first ploughing helps to neutralize soil acidity, promoting better microbial activity and improving the soil structure. Allowing it to sit for a few days helps the amendments to integrate into the soil. The subsequent application one month after sowing provides a continued source of essential nutrients, particularly calcium and magnesium, which support plant development.
		Organic manure Application of compost at the rate of 100 kg/acre.	Enriches soil fertility, improves soil structure, enhances moisture retention, and supports beneficial microbial activity, leading to healthier crops and better yields.

		Phosphate application After the second round of ploughing, apply rock phosphate in the necessary amount based on soil test results.	Applying rock phosphate after the second round of ploughing improves soil phosphorus levels, which is vital for root development, flowering, and fruiting in crops. Tailoring the application based on soil test results ensures that the right amount is used, preventing over-application and minimizing environmental impact. This practice enhances nutrient availability, promotes healthy plant growth, and can lead to increased crop yields and overall soil fertility
		Companion Planting: Plant marigold or chrysanthemum at the time of sowing, along the bunds to repel pests such as stem borer.	Planting marigold or chrysanthemum along the bunds acts as a natural pest repellent, particularly against pests like stem borer. These flowers release compounds that deter harmful insects while attracting beneficial ones. This practice enhances biodiversity, reduces the need for chemical pesticides, and can lead to healthier crops and improved yields.
2	Seed selection	Uma / D1	
	Seed rate	30 kg/acre	
	Seed treatment	Dip the seeds in a salt solution made by dissolving 1.5 kg of salt in 100 liters of water. This method will help separate the half-filled seeds before treatment. After separation, wash the seeds thoroughly with water twice.	

		Then soak the seeds in water for 12 to 16 hours before sowing. After soaking, spread them out in a shaded area to dry slightly. Then, sow the seeds mixed with PGPR 2 at a rate of 800g/acre.	Mixing seeds with PGPR 2 (Plant Growth-Promoting Rhizobacteria) enhances seed germination and root development, leading to stronger plant growth. Additionally, PGPR improves nutrient uptake and can increase resistance to diseases and stress, resulting in higher crop yields and better overall plant health.
3	Mode of sowing	Nursery preparation Prepare the land by ploughing with a tractor, and leveling it using a wooden plank. Sow the germinated seeds, which have been soaked in water for 12 to 48 hours, mixed with PGPR 2 at a rate of 800g/acre.	
		At 15-20 DAS, apply a 1% urea spray.	Spraying urea on seedlings in the nursery provides a quick source of nitrogen, promoting vigorous growth.
		One day before transplanting, spray a Pseudomonas solution onto the paddy hills.	Spraying a Pseudomonas solution onto paddy hills one day before transplanting helps establish beneficial bacteria that enhance root development, improve nutrient uptake, and increase plant resilience against diseases, leading to healthier crops and potentially higher yields.
		After 21-24 days of sowing, the seedlings will be ready for transplanting.	

4	Watering protocol	0 DAS- 5 cm water film while sowing 5 DAS- draining the field 15 DAS- after weedicide application irrigating the field 20-22 DAS - draining 25 DAS -Watering the field (after 24 hours of first round of fertilizer application) 35 DAS- By the time field almost become dry and water again 40-44 DAS -Again the field becomes dry. Application of fertilizer (2nd round). 45 DAS -Watering 55 DAS -Watering 65 DAS -watering 75 DAS- watering 85 DAS -watering 95 DAS -watering 105 DAS -watering No watering further	
5	Weed management	Weedicide application at 2-3 leaved stages of weeds-	
		Apply Londax Power at 4Kg/acre ors Mix 1 liter of Vivaya and 14 grams of Affinity in 100 liters of water for controlling broadleaved weeds and sedges. Apply using a floodjet nozzle.	- Promotes sustainable practices by using specific herbicides in a targeted manner, reducing the need for multiple applications. - Using a floodjet nozzle ensures uniform coverage and better penetration of herbicide over dense weed canopies, enhancing weed control efficiency.
		Drain the field before applying the herbicide. Water the field 48 hours after herbicide application, then drain again and apply the first dose of fertilizer.	- Enhances nutrient availability, as draining before application ensures the herbicide works effectively, and watering afterward aids nutrient absorption. - Improves resource use by applying the herbicide before flooding, minimizing water contamination and optimizing effectiveness.

		KAU Weed Wiper Kerala Agricultural University, for the post-emergence management of weedy rice by direct contact application (DCA) of broad-spectrum non-selective herbicides using specially designed novel hand held weed wiper device could selectively dry the panicles of weedy rice at 55-60 DAS, taking advantage of the height difference of 15-20 cm between weedy rice and cultivated rice. DCA can be effectively done in weedy rice infested cropped fields using non-selective herbicides, viz. glufosinate ammonium, 100ml/L	The use of a handheld weed wiper for direct contact application of non-selective herbicides effectively targets and dries out weedy rice while minimizing harm to cultivated rice due to the height difference. This method promotes efficient weed management, reduces competition for resources, and enhances crop yield without extensive labor or chemical use, leading to more sustainable farming practices.
			During the survey, farmers expressed their opinions that this practice is labor-intensive and that they are facing a shortage of skilled labor. Moreover, those cultivating on leased land tend to prioritize profit, leading them to show little interest in adopting sustainable practices.
6	Fertilizer application	3 rounds of fertilizer application 5 DAT- 10kg urea+ 2kg neem cake and 15kg potash 25 DAT- 25 kg urea and 15kg potash. 50 DAT-25 kg urea and 15 kg potash	Applying urea mixed with neem cake provides a dual benefit to crops. The urea supplies a quick-release source of nitrogen, promoting healthy plant growth, while the neem cake acts as a slow-release organic fertilizer, enhancing soil fertility over time. Additionally, neem cake helps suppress soil-borne pests and diseases due to its natural insecticidal properties, improving overall plant health and resilience.
		Sampoorna Micronutrient mix application Application at 30 DAT and 50 DAT at the rate of 10 grams per liter of water	Enhances nutrient availability, ensuring crops receive essential micronutrients for optimal growth and development.

		Use Leaf Color Chart at 20 DAT Utilize a leaf color chart to assess the nitrogen status of plants. By comparing leaf color with the chart, the precise amount of nitrogen fertilizer needed for optimal growth and nutrient balance can be determined . This practice enhances efficiency in fertilizer application and promotes healthier crops.	This practice enhances efficiency in nitrogen fertilizer application and promotes healthier crops.
7	Pest and disease management	Bacterial leaf blight • Application of bleaching powder @ 5 kg ha-1 in the irrigation water 30 DAS is recommended for preventing the spread of bacterial leaf blight • Conduct the ooze test to confirm the presence of bacteria if symptoms are observed. • Spray fresh cow dung extract. Dissolve 20 g of cow dung in one liter of water, let it settle, and then sieve it. Use the supernatant liquid for spraying. • Pseudomonas spray (5gm/L)	The chlorine in the bleaching powder can reduce harmful pathogens in the water, preventing their spread to the fields.
		• Kcycline/ tagmicin (A broad-spectrum chemical bactericide that contains a combination of Streptomycin Sulphate and Tetracycline Hydrochloride) (30g) + nativo (50g) per acre	K-cyclin and Tagmycin target bacterial pathogens, while Nativo provides fungicidal properties, creating a synergistic effect. This combination reduces disease incidence, promotes healthier plants.
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		Blast • Nativo (Trifloxystrobin+Tebuconazole) 80g in 200L for 1 acre (Nativo has phytotonic effect) Bug • Prepare a fish amino acid solution at a rate of 15 ml per liter of water. Spray it around the infested area, starting from the periphery and moving inward to encourage the pests to move toward the center. • Since the occurrence of the bug coincides with the flowering stage, application of the insecticide may be done either before 9 a.m. or after 3 p.m. so that fertilization of the flowers is not adversely affected.	Experts have suggested certain methods to control caseworm and armyworm; But farmers see it as less practical. Case worm • A rope soaked in kerosine is passed over the young crop for dislodging the larval cases from the tillers and then the water is drained for eliminating them. Army worm • Flood the fields for 7–14 days after armyworm larvae hatch to drown them and control their population.
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8	Harvesting	1. Optimal Timing of Harvest Recommend harvesting when 80-85% of the grains are mature, ensuring maximum grain yield and quality. Early harvesting can lead to immature grains, while late harvesting increases the risk of shattering and pest damage.	

		2. Recommended Harvesters Use lightweight combine harvesters that are better suited to Kerala's wetland fields, such as those in Alappuzha. These lightweight harvesters reduce soil compaction, making them ideal for regions where soil structure is a concern. The Kubota DC-70G and Yanmar Combine Harvester are recommended due to their efficiency and adaptability to various field conditions. For added convenience and efficiency, a harvester with a long handle discharge system is preferable. Harvesters equipped with grain tank discharge augers allow the direct transfer of harvested rice into a storage container, minimizing grain spillage and reducing additional labor costs. Such machines are beneficial as they cut down on the time and manual effort needed for transferring grains after harvesting.	
		3. Standardized Price for Harvester Hiring To reduce exploitation by harvester agents, a standardized hiring cost per hour or per acre should be implemented and agreed upon by agricultural cooperatives. These bodies can collaborate with local government authorities to establish a fair rate, ensuring transparency and affordability. The current standard price should be reviewed annually, considering factors like fuel costs, labor wages, and seasonal demand.	
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		4. Insurance Premium and Subsidy Premium Rates for Farmers: • Farmers are required to pay a nominal premium, typically 2-3% of the sum insured • The government of Kerala provides a premium subsidy, covering the remaining premium amount beyond what the farmers pay, making the scheme affordable.	
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		6. Enrollment Process Farmers can enroll through their local Krishi Bhavan, cooperative societies, or banks. Farmers need to submit the following documents for enrollment: • Aadhaar card • Land ownership proof or lease agreement for tenant farmers • Bank account details	
		7. Claim Process • Loss Assessment: Loss assessment is carried out through Crop Cutting Experiments (CCEs), conducted by teams comprising representatives from the Agriculture Department, Revenue Department, and insurance companies. • Claim Settlement: Claims are settled directly into the farmers' bank accounts through Direct Benefit Transfer (DBT)	
		2. Pradhan Mantri Fasal Bima Yojana (PMFBY) The Pradhan Mantri Fasal Bima Yojana (PMFBY) is a government-backed crop insurance scheme aimed at providing financial support to farmers in the event of crop failure. Launched by the Government of India in 2016, PMFBY helps farmers manage the risks involved in agriculture due to adverse weather conditions, pests, and diseases. Here are the key details:	
		1. Objectives • To provide insurance coverage and financial support to farmers in the event of crop failure due to natural calamities, pests, and diseases. • To stabilize farmers' incomes, ensuring their continuous engagement in farming. • To encourage farmers to adopt innovative and modern agricultural practices. • To ensure flow of credit to the agriculture sector.	

		2. Coverage PMFBY provides comprehensive coverage to farmers for: • Prevented Sowing/Planting Risk: Coverage is provided when a farmer is unable to plant the crops due to adverse weather conditions. • Standing Crop Loss: Insurance is provided for crop damage during the growing season due to drought, flood, hailstorm, pest attacks, and other risks. • Post-Harvest Losses: Coverage for crops that suffer damage due to unseasonal rainfall or hailstorms after harvest. • Localized Calamities: Coverage against specific localized risks such as hailstorms, landslides, or floods.	
		3. Eligibility • Eligible Farmers: All farmers growing notified crops in the notified areas, including: o Loanee Farmers: Those who have taken loans from financial institutions are automatically covered under the scheme. o Non-Loanee Farmers: Those who do not have crop loans but voluntarily wish to avail of insurance coverage.	
		4. Insurance Premium and Subsidy • Premium Rates for Farmers: o Kharif Crops (Monsoon Season): 2% of the sum insured. o Rabi Crops (Winter Season): 1.5% of the sum insured. o Commercial and Horticultural Crops: 5% of the sum insured. The government (central and state) provides a significant premium subsidy, which covers the remaining premium amount beyond what the farmers pay. The subsidy helps keep premiums affordable.	

		5. Sum Insured • The sum insured is calculated based on the Scale of Finance (SoF) decided by the District Level Technical Committee (DLTC). It reflects the cost of cultivation for the crop and varies depending on the crop type and location.	
		6. Enrollment Process • Offline: Farmers can enroll through their local Krishi Bhavan, cooperative societies, or banks. • Online: Farmers can register on the PMFBY portal (https://pmfby.gov.in/) or through the National Crop Insurance Portal. Farmers need to submit the following documents for enrollment: • Aadhaar card • Land ownership records or proof of land lease for tenant farmers • Bank account details • Crop sowing certificate (provided by the agricultural office)	
		7. Claim Process • Crop Cutting Experiments (CCEs): The yield of a particular area is assessed using crop-cutting experiments (CCEs) conducted at the end of the crop season. The claim process is triggered when the assessed yield is less than the threshold yield. • Prevented Sowing Claims: Claims are initiated if farmers are unable to sow their crops due to adverse climatic conditions. • Claim Settlement: Claims are settled directly into the farmers' bank accounts through Direct Benefit Transfer (DBT).	

8. Key Features

- Wide Coverage: Covers a variety of crops, including cereals, pulses, oilseeds, and horticultural crops.
- Area Approach: The scheme follows an area-based approach, meaning insurance is offered to farmers within a defined geographical region notified for insurance purposes.
- Technology Use: PMFBY uses technology for yield estimation (through satellite imaging, remote sensing, drones) and faster claim settlements.

3. Restructured Weather Based Crop Insurance Scheme (RWBCIS)

The Restructured Weather Based Crop Insurance Scheme (RWBCIS) is a crop insurance scheme launched by the Government of India to protect farmers against potential financial losses due to adverse weather conditions affecting their crops. Unlike traditional yield-based insurance, RWBCIS provides compensation based on weather data that can influence crop productivity. Here are the detailed aspects of RWBCIS:

1. Objectives

- To provide insurance coverage to farmers against weather-related risks, such as unseasonal rainfall, high temperatures, humidity, wind speed, etc.
- To stabilize farmers' income by compensating them for financial losses due to adverse weather.
- To encourage farmers to adopt climate-resilient agricultural practices.

2. Coverage

RWBCIS covers weather-related risks that can impact crop growth, development, and productivity. The scheme provides coverage for:

- Adverse Weather Conditions: Excess or deficit rainfall, extreme temperatures (heat or cold waves), high relative humidity, and strong winds.
- Critical Crop Stages: Weather risks are covered based on different growth stages of the crop, such as germination, flowering, and maturation.

3. Eligibility

- Eligible Farmers: All farmers growing notified crops in the notified areas are eligible to avail of the scheme.
    - Loanee Farmers: Farmers who have taken crop loans are automatically enrolled.
    - Non-Loanee Farmers: Voluntary enrollment is open for non-loanee farmers.

4. Premium Charges and Subsidy

- Premium Rate:
    - Farmers pay a premium of 1.5% of the sum insured for food crops and oilseeds.
    - For commercial and horticultural crops, the premium can go up to 5% of the sum insured.
- Government Subsidy:
    - The central and state governments provide a subsidy on the remaining premium, which can cover 75% to 95% of the total premium.
    - The subsidy helps make the insurance affordable for small and marginal farmers.

5. Sum Insured

- The sum insured is determined based on the cost of cultivation per hectare of the crop, and it varies from crop to crop and region to region.
- It reflects the average yield and expected value of the crop as per local norms.

6. Enrollment Process

- Offline: Farmers can apply for the scheme at their local Krishi Bhavan, cooperative societies, or designated commercial banks.
- Online: Enrollment is available through the RWBCIS portal or the National Crop Insurance Portal.

Farmers need to submit:

- Aadhaar card
- Land records or proof of land lease
- Bank account details
- Crop sowing certificate

		7. Claim Process • Automatic Trigger: Claims are automatically triggered based on weather data collected from designated automatic weather stations (AWS). There is no need for physical inspection or crop-cutting experiments. • Weather Index: The scheme uses a weather index that sets certain thresholds for each weather parameter (e.g., temperature, rainfall). If these thresholds are breached, the insurance payout is triggered. • Payouts: Claims are calculated based on the deviation of actual weather data from the pre-specified index, and payments are directly credited to the farmer's bank account through Direct Benefit Transfer (DBT).	
		8. Key Features • Weather Parameter Coverage: The scheme covers a wide range of weather parameters, including rainfall, temperature, humidity, and wind speed, which are crucial for crop growth. • Index-Based Payouts: RWBCIS uses pre-defined weather parameters as triggers for insurance payouts.	
11	Other	Ensure the construction of proper drainage channels and bunds to manage water flow and prevent flooding in the field.	

3.4. CONCLUSION

In conclusion, farmers are struggling to accurately prioritize the challenges they face in rice farming, viewing it primarily as an economic act. Only 1% of the surveyed farmers consume what they produce, while the rest sell their rice to Supplyco. Those who sell to Supplyco rely on chemical fertilizers, pesticides, and insecticides without considering the environmental impact. Some regions still use banned herbicides like Roundup, which pollute the soil, harm beneficial soil microbes, contaminate water sources, and pose health risks to consumers.

A study by Meethu Mohan et al. (2020) examined the physico-chemical attributes of paddy fields in Chathannoor, Kollam district, Kerala, with a focus on heavy metal content before sowing and after harvest. The research revealed that average heavy metal levels in the soil were higher before sowing than after harvest, indicating potential contamination from agricultural practices. It highlighted that the direct application of chemical fertilizers and the use of pesticides during the growing season contribute to elevated heavy metal concentrations in the soil. Similarly, Kannan et al. (2010) emphasized the deterioration of groundwater quality in paddy-dominated areas due to anthropogenic activities, including the overuse of chemicals. Their research revealed that these practices contribute to harmful changes in groundwater composition, further stressing the need for sustainable agricultural practices to protect water resources from pollution.

Farmers exhibit only a little concern for the quality of the rice they produce, focusing solely on maximizing profits. This focus drives them to apply a wide range of chemicals to boost production, disregarding sustainable practices. In Kerala, this approach is not sustainable; despite the government's guarantee to purchase whatever farmers produce, they prioritize quantity over quality. While farmers recognize that the cost of production is rising due to the high doses of chemicals they use, many remain unaware of the long-term impacts of overusing chemical fertilizers on both the environment and their crops.

Very few farmers are taking the advice of scientists and other experts in the field regarding farming practices and addressing challenges. Fertilizer and insecticide application is primarily governed by major companies in the sector, with agricultural officers also involved. While the landowners farm their land themselves, they have been trying to minimize pollution and improve the quality of the rice. However, most of the pattakrishi (rental or lease) farmers engage in aggressive farming with potentially harmful chemicals, aiming for maximum output. They are the least concerned with climate-related issues.

The development of the Climate Resilient Rice Farming Protocol represents a strategic step toward addressing the multiple vulnerabilities faced by Kerala's paddy sector. By integrating the best practices documented from successful farmers with the technical guidance provided by agriculture officials and scientific institutions, the protocol offers a comprehensive, field-validated approach to sustainable rice cultivation. It emphasizes adaptive practices such as timely sowing adjustments, the use of climate-tolerant varieties, water-efficient irrigation, soil health management, eco-friendly pest control, and post-harvest resilience strategies.

This protocol is designed to be region-specific, scalable, and practical, ensuring that farmers across diverse agro-ecological zones in Kerala can adopt measures that enhance productivity while minimizing environmental impact. By promoting climate resilience at the farm level, the protocol not only safeguards rice production but also contributes to food security, livelihood stability, and ecological conservation in the face of increasing climate uncertainties.

- In Kerala, 48% of rice farmers cite climate change as their primary concern, significantly impacting agricultural practices across diverse agro-climatic zones.
- Cost hikes in essential inputs, such as seeds, fertilizers, and labor, are reported by 10% of farmers, while 5% face shortages of these critical resources, hindering productivity and crop yields.
- Rice farmers in Alappuzha encounter challenges from flooding, irregular rainfall, untimely rainfall, and high temperatures, worsened by the low-lying geography of Kuttanad, where production occurs below mean sea level.
- The unique topography of Kuttanad increases vulnerability to climate change, disrupting the crop calendar and complicating planting and harvesting schedules.
- In Thrissur, farmers deal with high ambient temperature, untimely rainfall, poor-quality seeds, and significant weed and pest infestations, particularly in the kole lands with distinct hydrological conditions.
- Agro-climatic variability in Thrissur leads to differing soil fertility and water availability, affecting crop yields and crop calendar.
- In Palakkad, farmers experience excess rainfall, localized rains, and flash floods, influenced by the region's distinct climate patterns shaped by monsoonal winds, higher temperatures and topographical features.
- These changing conditions create an environment conducive to disease infestations, such as leaf blight, which threaten the viability of local rice crops. High labour cost is also emerging as a pressing issue there. Additionally, the irregularity of rainfall and high ambient temperatures exacerbate stress on crops, making it difficult for farmers to sustain yields.
- In Kottayam, high cultivation costs driven by increased labor, fertilizer, and post-harvest expenses significantly challenge farmers, compounded by flooding and untimely rainfall that disrupt production.
- A climate-resilient farming protocol was developed for both broadcasting and transplanting systems, addressing the key challenges identified. The protocol was scientifically validated in consultation with experts in this field to ensure its practical relevance and technical soundness.

3.6. REFERENCES

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CHAPTER 4
Implementation of Climate-Resilient Rice Farming Protocol and Evaluation

4.1 INTRODUCTION

Following the finalization of the climate-resilient rice farming protocol, field-level implementation was initiated to validate its practical feasibility, assess farmer acceptance, and document region-specific challenges. The interventions were deployed across selected paddy farming clusters in four major rice-growing districts of Kerala, representing diverse agro-ecological conditions.

The implementation strategy followed a participatory model, engaging Padasekhara Samithis to mobilize farmer involvement. Through consultative meetings, farmers were introduced to the recommended practices, and their feedback was incorporated into the deployment plan. This collaborative approach fostered ownership, adaptive learning, and alignment between scientific recommendations and field realities. Each participating Samithi provided a formal agreement letter, confirming their willingness to adopt and implement the protocol. Similar agreement letters were also collected from conventional Samithis to ensure their cooperation in sampling and data collection.

To support effective implementation, continuous assistance mechanisms were established. Real-time communication, advisory services, and periodic field monitoring ensured that the recommended practices were consistently translated from protocol to practice. Additionally, project management committee meetings were convened to review field-level observations, analyze collected data, and address operational challenges, creating an ongoing feedback loop for refinement and adaptive management.

To assess the degree of adherence to the prescribed protocol and to enable a comparative analysis with conventional farming systems, a scorecard system was developed. This tool evaluated the extent to which farmers implemented the recommended climate-resilient and sustainable practices, with higher scores indicating stronger compliance. The scorecard also helped identify gaps in adoption and provided insights into the operational performance of climate-resilient versus conventional farming systems.

Further, to evaluate the real-world impact of climate-resilient paddy cultivation, an index-based assessment framework was employed. This framework incorporated multiple dimensions of sustainability, including environmental safety, economic viability, productivity, technological adoption, and climate resilience. Each index was contextualized to reflect the local agro-ecological conditions, farming practices, and climate-related challenges in the study areas. This localized assessment provided a practical understanding of how the protocol performed across different regions, guiding both policy decisions and region-specific adaptive strategies.

A post-harvest survey was also conducted to capture a comprehensive picture of rice cultivation practices and outcomes in both climate-resilient and conventional systems. The survey gathered detailed data on cost of cultivation, from land preparation to post-harvest management, with special emphasis on post-harvest expenses, such as drying, storage, and transportation. In addition to financial aspects, the survey documented input usage, labour patterns, yield variations, and pest and disease management strategies.

Special focus was placed on evaluating the extent of farmers' direct participation in cultivation, distinguishing between those actively involved in farming operations and those relying largely on hired labour. The involvement of the younger generation in paddy cultivation was also assessed, given its significance for the long-term sustainability of rice farming in Kerala. Furthermore, the survey explored the reasons why farmers continue to cultivate paddy despite multiple challenges, such as rising input costs, labour shortages, climatic risks, and market volatility.

Through this multidimensional assessment, the study aimed to generate a holistic understanding of the economic, social, and operational realities of rice farming in Kerala, providing the basis for a nuanced comparison between climate-resilient and conventional approaches.

4.2 METHODOLOGY

4.2.1. Selection of Climate Resilient Fields (CRF) & Conventional (Control) Fields (CF)

In each identified district, one Padasekhara Samithi was selected based on the interest of farmers to implement the climate-resilient protocol. Meetings were conducted in these Samithis to introduce the proposed interventions and secure their participation. A neighbouring Samithi with comparable agro-climatic conditions, continuing with conventional practices, was selected as a control site to facilitate comparative assessment. A pre-season survey using a structured questionnaire (Appendix VIII) was conducted among farmers in the collaborating Samithis to document information on previous cropping practices, input use, and cost patterns.

4.2.2. Implementation Support and Field Monitoring

To ensure smooth adoption of the climate-resilient protocol, a structured support system was established alongside field-level implementation. WhatsApp groups were created in each district to facilitate real-time communication, enabling timely dissemination of advisories, reminders, and technical information during key stages of the cropping cycle. These digital platforms were complemented by periodic telephonic follow-ups to clarify farmer doubts, provide agronomic instructions, and resolve emerging issues. Throughout the cropping season, periodic field visits were conducted by the project team to monitor adherence to the protocol, assess field conditions, and offer on-site technical guidance.

4.2.3. Compliance with the Specific Practices of Climate-Resilient Paddy farming Protocol

A structured scoring index has been developed to evaluate farmers' adherence to recommended paddy farming practices. In this system, each recommended practice or technology is assigned a maximum score of 10, representing full compliance with the prescribed protocol. Farmers are assessed based on how closely their actual practices align with these recommendations, and scores are awarded accordingly.

The total number of recommended practices—and thus the maximum possible score varies by region. The total score for each district was calculated based on the number of improved technologies and practices recommended specifically for that district, reflecting localized agronomic and ecological needs. In Alappuzha and Kottayam, a total of 11 practices are recommended, resulting in a maximum score of 110. In contrast, Palakkad and Thrissur have 9 recommended practices, making their maximum score 90.

Each farmer's overall adherence score was calculated by summing the individual scores assigned for each recommended practice. The district-level adherence was then computed by taking the mean of these individual farmer scores within each district. This average score was subsequently converted into a percentage to derive the overall percentage adherence to the climate-resilient protocol in each district.

4.2.3.1. Scoring Index for Individual Practices

The following table outlines the scoring criteria assigned to different levels of adherence to each recommended practice. The scores reflect how closely the farmer's actions align with the prescribed methods. Full adherence is rewarded with a score of 10, while partial or non-compliance is scored proportionally lower.

I. Proposed practices

Table 4.1. Scoring criteria for assessing adherence to proposed practices

10	0
Following the proposed practice	Not following the proposed practice

II. Pest management

Table 4.2. Scoring criteria for assessing adherence to proposed pest management practices

10	7.5	6.5	6	5	4	0
*No application of Pesticides *Exclusive application of trichocard	Application of Trichocard with recommended pesticide	Application of Trichocard with recommended pesticide and an additional different pesticide	Exclusive use of any one or all of the recommended pesticides (without Trichocard)	Application of Trichocard with a non-recommended pesticide	Application of a proposed pesticide along with a non-recommended pesticide	Application of non-recommended pesticides

III. Weed management

Table 4.3. Scoring criteria for assessing adherence to proposed weed management practices

10	7.5	5	4	0
No application of weedicides/ manual weeding	Application of the proposed combination of weedicides	Application of only one of the proposed weedicides	Application of a proposed weedicide along with a non-recommended weedicide	Application of non-recommended weedicide

IV. Insurance

Table 4.4. Scoring criteria for assessing adherence to insurance uptake

10	5	0
Availed both State Insurance and Central Gov Insurance	Availed either State Insurance or National Insurance (only one)	Not availed either form of insurance

4.2.4. Evaluation of Climate-Resilient Paddy Cultivation Protocol during Puncha season in Kerala

A structured index system was developed to assess the performance and effectiveness of a newly introduced climate-resilient cultivation protocol. This system enables a multi-dimensional evaluation of environmental safety, economic viability, productivity, technological adoption, and resilience to climate stress.

The index framework comprises five core indices:

- Reduced Toxicity Index (RTI)
- Cost Effectiveness Index (CEI)
- Yield Potential Index (YPI)
- Adoption of Improved Techniques Index (AITI)
- Weather Pattern Impact Index (WPII

4.2.4.1. Reduced Toxicity Index

The RTI is a composite metric designed to assess the environmental and human safety of plant protection practices. It considers both the chemical nature and application behavior, with a scoring system from 2.5 (high risk) to 10 (low toxicity/safe).

Sub-Indices and Scoring Criteria:

I. Type of Chemical Used

This sub-index evaluates the toxicity of plant protection measures based on their label classification (Red, Yellow, Blue, Green). The scoring reflects the level of hazard to human health and the environment, with green-labeled or biocontrol methods scoring highest (10) and red-labeled, highly toxic chemicals scoring lowest (2.5).

Table 4.5. Scoring criteria for type of chemical used in plant protection

Label / Category	Score	Description
Red Label	2.5	Extremely hazardous
Yellow Label	5	Moderately hazardous
Blue Label	7.5	Slightly hazardous
Green Label	10	Low-risk chemicals/ biocontrol methods

II. Dosage per Application

This assesses how much chemical is applied relative to the recommended safety guidelines. Using lower or need-based doses scores higher, indicating more precise and responsible use, whereas overdosing practices receive lower scores due to increased risk to health and ecosystems.

Table 4.6. Scoring criteria for dosage of plant protection chemicals

Dosage Category	Score	Description
Overdose	2.5	Overuse beyond recommended dosage
Moderately overdose	5	Higher end of label recommendation
Recommended dosage	7.5	Follows recommended guidelines
Lower dosage	10	Precision or need-based application only

III. Frequency of Application

This sub-index measures how often chemicals are applied during the crop season. Frequent applications indicate chemical dependency and lower score, while reduced or no application (organic or biocontrol-based approaches) receive higher scores for minimizing environmental impact.

Table 4.7. Scoring criteria for frequency of chemical application

Frequency (per-season)	Score	Description
>5 times	2.5	Heavy dependency on chemicals
3–4 times	5	Moderate use
1–2 times	7.5	Low frequency
None	10	No chemical application/Fully organic/ biocontrol-based

IV. Stage of Crop Growth at Application

This examines the timing of chemical use during the crop cycle. Later-stage applications, especially near harvest, increase the risk of residue in grains and hence score poorly. Early-stage chemical application and no chemical application score high due to their lower impact on final produce and ecosystems.

Table 4.8. Scoring criteria for crop stage at time of chemical application

Stage of Application	Score	Description
Flowering or near harvest (After 60 DAS)	2.5	High residue risk
Mid-growth stage (30–60 DAP)	5	Moderate impact
Early vegetative / pre-sowing (Upto 30 DAS)	7.5	Lesser impact
None	10	Safest option

V. Risk of Environmental Pollution

This considers the proximity of application areas to water bodies, assessing the risk of pesticide runoff or spray drift. Fields closer to canals or rivers pose a higher pollution risk and score lower, while those farther away, especially with natural barriers, are safer and receive higher scores.

Table 4.9. Scoring criteria for environmental pollution risk from chemical use

Proximity to Water Bodies	Score	Description
Close to irrigation canal/river	2.5	Unsafe spraying near water; high drift risk
Moderate proximity	5	Some risk; limited barriers
Away from water bodies	7.5	Safe distance; some natural protection
Far away	10	Very low risk due to distance and barriers

4.2.4.2. Cost Effectiveness Index

The CEI evaluates economic efficiency by measuring both input costs and profitability, along with the potential for cost reduction over time.

Sub-Indices and Scoring Criteria:

I. Total Cost per Acre

Measures overall expenditure on cultivation per acre. Lower costs score higher, reflecting better resource efficiency.

Table 4.10. Scoring criteria for total cultivation cost per acre

Total Cost (₹/acre)	Score
> 30,000	2.5
25,001–30,000	5
20,001–25,000	7.5
≤ 20,000	10

II. Net Profit per Acre

Captures profitability from farming. Higher profits yield higher scores, indicating better economic returns.

Table 4.11. Scoring criteria for net profit per acre

Net Profit (₹/acre)	Score
≤ 1,000 or loss	2.5
1,001–5,000	5
5,001–10,000	7.5
> 10,000	10

III. Cost Reduction Compared to Previous Season

Evaluates how much cost savings were achieved over the previous season. Greater savings reflect improved input optimization.

Cost Reduction %= (Previous Cost – Current Cost)/(Previous cost)*100

Table 4.12. Scoring criteria for cost reduction compared to previous season

Cost Reduction	Score
No reduction / Increased	2.5
1–10% saved	5
10–25% saved	7.5
>25% saved	10

4.2.4.3. Yield Potential Index (YPI)

The YPI captures the productivity performance of the climate-resilient protocol, focusing on both absolute yield and improvement over past performance.

Sub-Indices and Scoring Criteria:

I. Yield per Acre

Measures the quantity of paddy produced per acre. Higher yields score better, indicating improved productivity.

Table 4.13. Scoring criteria for yield per acre

Yield (kg/acre)	Score
< 1,500	2.5
1,500–2,500	5
2,500–3,500	7.5
> 3,500	10

II. Change of Yield Over Previous Season

Captures the percentage increase in yield over the previous season. Significant gains reflect better agronomic performance.

Yield Change %=(Current Yield – Previous Yield/Previous Yield)*100

Table 4.14. Scoring criteria for yield improvement over previous season

Yield Change	Score
Negative or 0	2.5
1–10	5
10–25	7.5
>25	10

4.2.4.4. Adoption of Improved Techniques Index

The AIT evaluates the use and effectiveness of improved sowing technologies such as seed drums or mechanical transplanters.

Sub-Indices and Scoring Criteria:

I. Adoption Level of Improved Equipment

Measures the percentage of farmers using improved sowing tools like seed drums or transplanters. Greater adoption means higher scores.

Table 4.15. Scoring criteria for adoption of improved sowing equipment

Adoption Rate (%)	Score
<25	2.5
25–50	5
50–75	7.5
>75	10

II. Sowing Uniformity / Crop Stand Quality

Observes the evenness of the crop stand in the field. A uniform and well-spaced crop indicates effective sowing techniques.

Table 4.16. Scoring criteria for crop stand uniformity and sowing quality

Crop Stand Observation	Score
Very poor / scattered	2.5
Uneven, better than manual	5
Mostly uniform, few gaps	7.5
Highly uniform and well-spaced	10

4.2.4.5. Weather Pattern Impact Index

The WPII assesses how the improved protocol helps mitigate the impacts of climatic variability on paddy farming operations.

Sub-Indices and Scoring Criteria:

I. Delay in Operations Due to Weather Events

Evaluates how long farming operations were delayed due to weather events (rainfall, drought, etc.). Less delay indicates better resilience.

Table 4.17. Scoring criteria for delay in operations due to weather events

Delay Duration (days)	Score
>14 days	2.5
8–14 days	5
3–7 days	7.5
0–2 days	10

II. Additional Cost Incurred Due to Weather Events

Captures extra financial burden caused by weather-related disruptions. Lower additional costs reflect stronger adaptive capacity.

Table 4.18. Scoring criteria for additional costs incurred from weather events

Additional Cost (₹/acre)	Score
> 4,000	2.5
2,001–4,000	5
501–2,000	7.5
0– 500	10

The composite index system presented above enables a holistic assessment of climate-resilient farming practices. By integrating five major indices — each with detailed sub-criteria — this tool allows for evidence-based decision-making. It helps identify successful interventions, monitor district-wise adoption, and refine adaptive strategies suited to Kerala's agro ecological and climatic diversity.

4.2.5. Post-Harvest Survey

The data collection involved direct interactions with farmers from the Padasekhara Samithis where the climate-resilient protocol was implemented, as well as from neighbouring control Samithis practicing conventional rice cultivation. Structured questionnaire (Appendix XIII) and field interviews were used to record stage-wise cost data, ensuring all key components were covered. Farmers provided information on expenses related to land preparation, such as ploughing, puddling, bund maintenance, and leveling, along with costs for seed procurement, nursery preparation, and transplanting. The survey also captured input costs, including fertilizers, lime, organic manures, bio-control agents, and plant protection chemicals. Labor expenses were recorded separately for each operation, such as weeding, irrigation, pest management, and harvesting, reflecting both manual and mechanized activities. Mechanization charges for equipment like tractors, drum seeders, and harvesters were also included, alongside costs related to irrigation and water management, particularly in regions like Kuttanad where dewatering operations are essential.

Post-harvest expenses, including bagging and drying, transportation, and loading/unloading, were documented in detail. In addition to cost-related data, the survey recorded farmers' perceptions of the challenges encountered during the season, such as labor shortages, pest and disease outbreaks, input supply constraints, weather-related disruptions like floods or droughts, and marketing difficulties. All responses were digitized to facilitate systematic analysis and comparison. This comprehensive survey provided critical insights into the economic viability and practical challenges of rice cultivation, forming the basis for evaluating the performance of climate-resilient farming interventions against conventional practices

4.3. RESULTS

4.3.1. Farmer Orientation Workshops on Climate-Resilient Paddy Farming

As part of the project, a series of farmer-oriented workshops were organized across Kerala's major rice-producing districts. These sessions aimed to introduce the Climate-Resilient Paddy Farming Protocol developed as part of the project, gather farmer feedback, and understand ground-level challenges in order to refine and adapt the protocol to local conditions.

The workshops facilitated direct interaction with farmer groups in Kottayam, Palakkad, Alappuzha, and Thrissur, providing insights into the diverse agro-ecological and socio-economic factors influencing paddy cultivation in each region. Farmers shared region-specific issues, including climate-related risks, pest and disease emergence, input cost hike, soil degradation, and cultural preferences for certain farming methods.

Based on these discussions, location-specific strategies were incorporated into the protocol. This approach ensured that the climate-resilient practices recommended were not generic but instead tailored to the actual needs, vulnerabilities, and capacities of farmers across the different districts. Each collaborating Samithi provided an agreement letter (Appendix VI) to formally confirm their willingness to implement the proposed protocol.

The following sections provide detailed documentation of the workshops held

4.3.1.1. Kottayam District – Kelakkari -Vattakkayal Nellulpadaka Samithi

An orientation workshop introducing the Climate-Resilient Paddy Farming Protocol was held on October 11, 2024, at Cheepungal, Arpookara, Kottayam. The event was organized by the Tropical Institute of Ecological Sciences (TIES) in collaboration with the Kelakkari Vattakkayal Nellulpadaka Samithi.

Shri Sreenivasan, Secretary of the Samithi, welcomed the participants, while President Surendran presided over the session. Dr. Punnen Kurian, Secretary of TIES, introduced the institute and outlined the objectives of the project. Ms. Habi Sherin, Project Coordinator, presented a detailed explanation of the climate-resilient farming protocol, which had been developed through extensive field observations and expert consultations.

The workshop was attended by 25 farmers who actively participated by raising queries and sharing insights based on their field experiences. Discussions highlighted the specific challenges faced in the Vattakkayal region, including waterlogging during monsoon, pest management issues, and input cost pressures.

The farmers expressed their willingness to implement the protocol, committing to discuss the details with other Samithi members in their forthcoming meeting scheduled for the end of the month. The event concluded with a vote of thanks by Project Assistant Mr. Aditya S. As a result of this engagement, localized strategies such as improved drainage management and integrated pest control were integrated into the protocol for Kottayam.

Fig 4.1. Samithi meeting in Kottayam

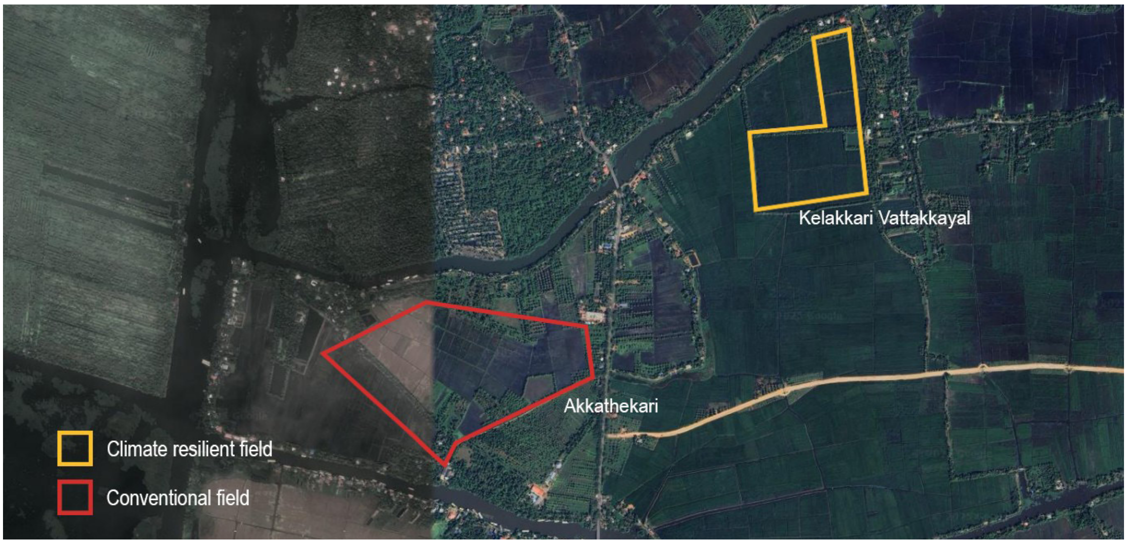


Fig 4.2. Selected Climate-Resilient and Conventional fields in Kumarakom (Kottayam)

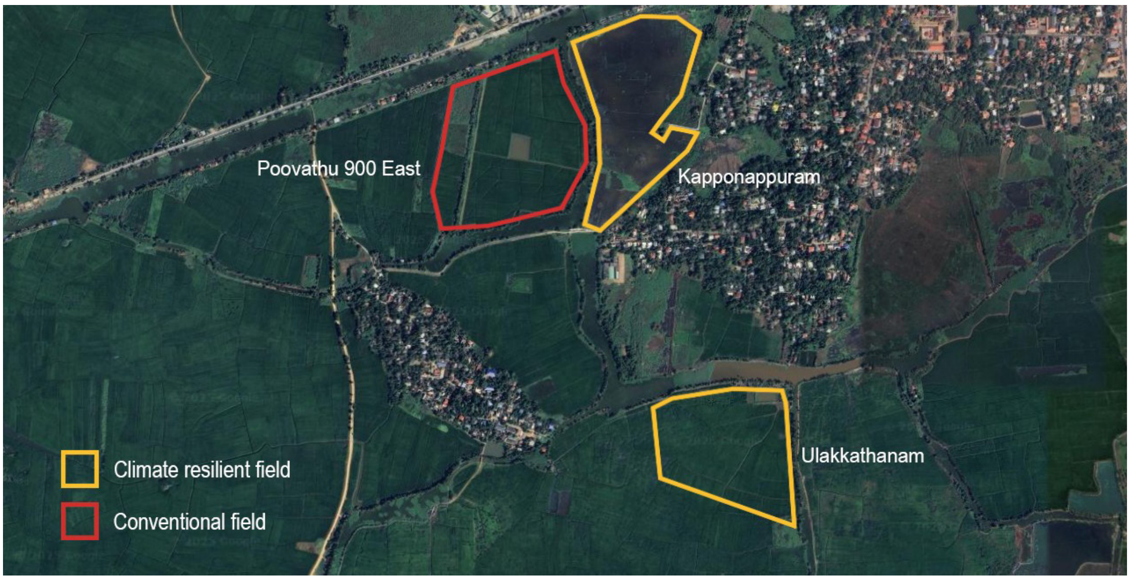


Fig 4.3. Selected climate-Resilient and Conventional fields in Changanassery (Kottayam)

4.3.1.2. Palakkad District – Koorodumannu Padasekhara Samithi

On October 14, 2024, a farmer-oriented workshop was conducted at Kattussery, Alathur, Palakkad, in collaboration with the Koorodumann Padasekhara Samithi. The session focused on introducing climate-resilient rice cultivation practices while understanding the region's unique agricultural dynamics.

Ms. Habi Sherin, Project Coordinator, delivered a comprehensive presentation on the newly developed protocol, emphasizing adaptation strategies co-developed with farmers, agricultural officers, and researchers. Mr. Gouthaman, Secretary of the Samithi, presided over the session, stressing the importance of shifting towards sustainable practices in the face of increasing climatic risks.

Dr. Punnen Kurian, Secretary of TIES, provided an introduction to the institute and outlined the project's objectives. The session also included contributions from Ms. Shruthy, Agricultural Officer of Alathur, and Mr. Anil P.K., Agricultural Assistant, who shared additional technical perspectives.

Twenty-five farmers attended the workshop and engaged in discussions focusing on specific issues such as delayed monsoons, labor shortages, and soil fertility decline. The farmers unanimously agreed to adopt the protocol and suggested further customizing it to address local realities. Based on these inputs, region-specific amendments such as labor-efficient practices and organic soil amendments were incorporated into the Palakkad version of the protocol. The workshop was coordinated by Project Assistant Mr. Aditya S.

Fig 4.4. Samithi meeting in Palakkad

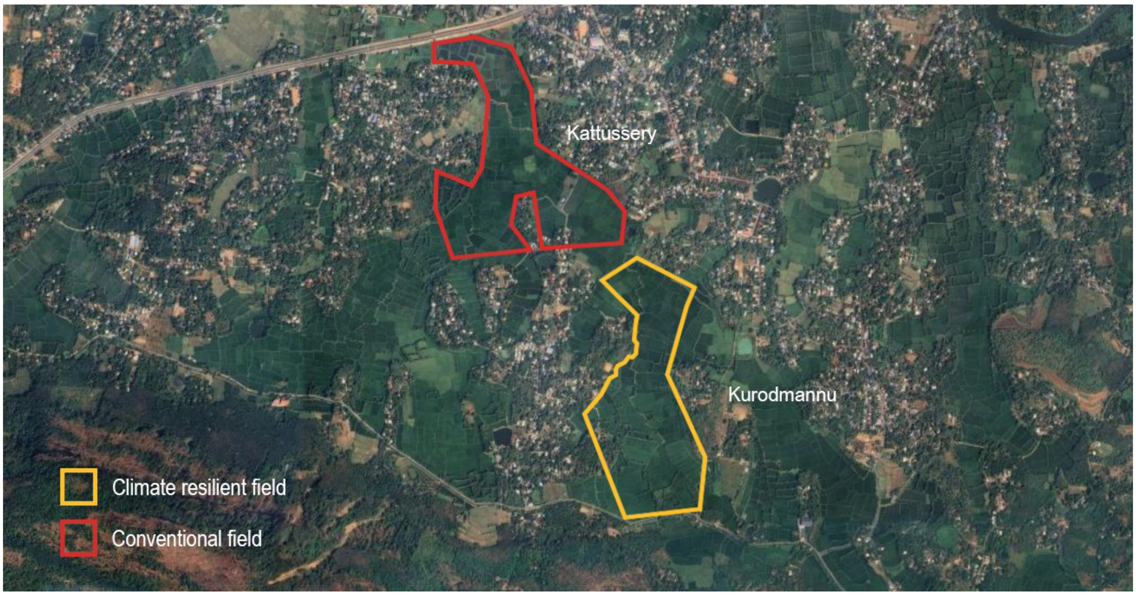


Fig 4.5. Selected Climate-Resilient and Conventional fields in Alathur (Palakkad)

4.3.1.3. Alappuzha District – Rajaramapuram Padasekhara Samithi, Kavalam

A farmer engagement session was held on October 15, 2024, at Cherukara SNDP Hall, Kavalam, Alappuzha, in collaboration with the Rajaramapuram Padasekhara Samithi. The event aimed to introduce climate-resilient paddy farming techniques to farmers in the low-lying Kuttanad wetland ecosystem, which is highly vulnerable to climate extremes.

Mr. A.J. Chacko, Secretary of the Samithi, welcomed the participants. Dr. Punnen Kurian, Secretary of TIES, provided an overview of the project's objectives, emphasizing the need for adaptive responses to erratic weather patterns and water management challenges. Ms. Habi Sherin, Project Coordinator, presented the Climate-Resilient Paddy Farming Protocol, elaborating on strategies to enhance productivity while conserving environmental resources.

The meeting was attended by 37 farmers who participated in a lively discussion on the specific challenges of paddy cultivation in the Kavalam region, including increasing flood frequency, salinity intrusion, and crop loss due to unexpected climate events.

Farmers expressed their readiness to implement the recommended practices, and additional suggestions were provided to tailor the protocol to suit wetland-specific constraints. Project Assistant Mr. Aditya S documented the event and provided technical support.

Fig 4.6. Samithi meeting in Alappuzha

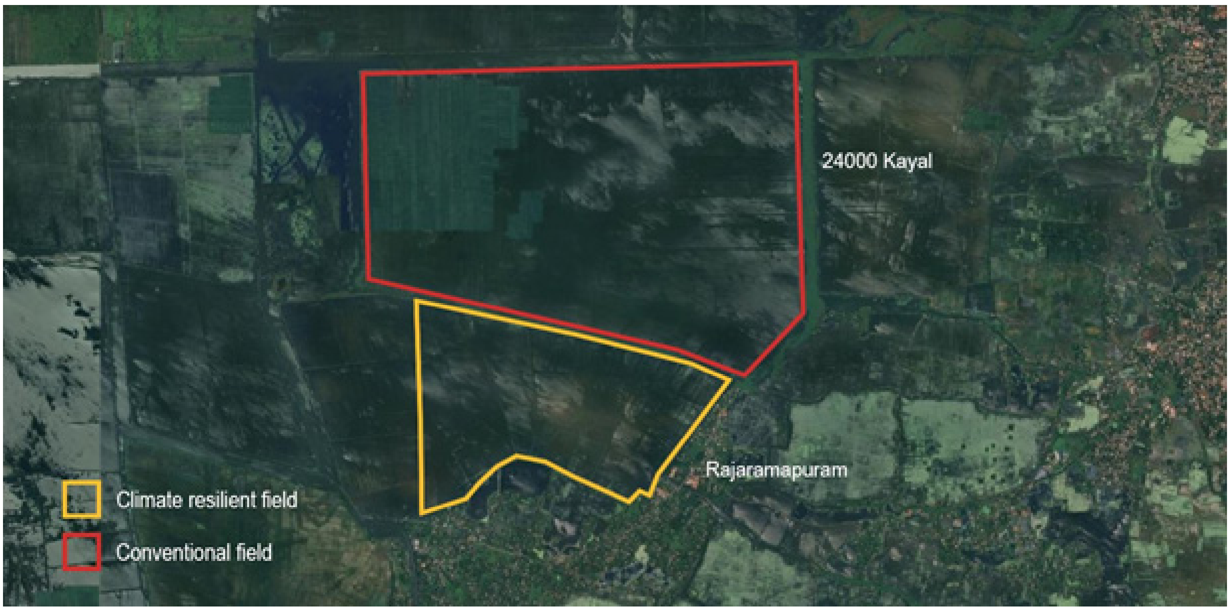


Fig 4.7. Selected Climate-Resilient and Conventional fields in Kavalam (Alappuzha)

4.3.1.4 Thrissur District

In Thrissur, four farmer meetings were held to introduce the Climate-Resilient Paddy Farming Protocol. While the first three Samithis declined to adopt the protocol due to internal coordination challenges and adherence to conventional practices, the fourth meeting resulted in an agreement to implement the protocol. These interactions helped identify key challenges in the kole lands, leading to the inclusion of region-specific strategies in the final protocol.

I. Kodannur Kole Farming Cooperative Society

A farmer engagement meeting was held on October 14, 2024, in Kodannur, Thrissur, in collaboration with the Kodannur Kole Farming Cooperative Society. The session was led by Mr. Pazhore Appukuttan, President of the Samithi, and Ms. Raji, Secretary of the Samithi. A total of 33 farmers participated.

Ms. Habi Sherin presented the climate-resilient farming protocol, and Dr. Punnen Kurian provided an introduction to the project goals. Farmers participated actively, raising concerns regarding field-level challenges. However, despite initial interest, the Samithi decided not to proceed with implementation, citing internal coordination difficulties that hindered consensus-building among members.

Fig 4.8. 1st Samithi meeting in Thrissur

II. Muriad Kayal Thekkepadam Kole Karshaka Samithi, Irinjalakkuda

A follow-up meeting was conducted on October 26, 2024, at Irinjalakkuda with the Muriad Kayal Thekkepadam Kole Karshaka Samithi. The workshop addressed the complex environmental threats to Kole wetlands, including urban encroachment, salinity, and declining mangrove buffers.

Although the session generated constructive discussion, the Samithi chose not to adopt the proposed practices. The primary reason was their adherence to traditional farming methods, which they had been following for generations. This highlighted the need for phased awareness-building and demonstrated the importance of respecting cultural continuity while introducing innovations.

Fig 4.9. 2nd Samithi meeting in Thrissur

III. Penakam-Punchakkol Padasekhara Nellulpadaka Samithi

On the same day, an orientation session was held in Penakam, Thrissur, in collaboration with the Penakam Punchakkol Padasekhara Nellulpadaka Samithi. Presentations were led by Ms. Habi Sherin and Dr. Punnen Kurian, with additional inputs from Agricultural Officer Ms. Amala.

Farmers shared concerns about rising costs, pest outbreaks, and machinery maintenance challenges. Despite a productive discussion, the group ultimately decided not to implement the protocol due to the internal disputes and cultural preferences for conventional practices passed down through generations.

Fig 4.10. 3rd Samithi meeting in Thrissur

IV. Joint Samithi Meeting – Vennippadam-Vadakke Bhagam Nellulpadaka Karshaka Samithi, Ponmani Karshaka Sangham, and Kachanipadam Samithi

A turning point in Thrissur district engagement occurred on December 14, 2024, during a joint meeting involving the Vennippadam Vadakke Bhagam Nellulpadaka Karshaka Samithi, Ponmani Karshaka Sangham, and Kachanipadam Samithi. The meeting, attended by 25 farmers, was presided over by the respective Samithi Presidents.

Ms. Habi Sherin introduced the Climate-Resilient Paddy Farming Protocol, followed by an address by Dr. Punnen Kurian on the necessity of adaptive farming. Farmers openly discussed their experiences managing kole fields, which are increasingly affected by changing rainfall patterns, flooding, and salinity.

This session resulted in a formal agreement to adopt the protocol, with the Vennippadam Vadakke Bhagam Nellulpadaka Karshaka Samithi agreeing to cooperate. Based on the feedback, modifications were made to include region-specific flood management practices, use of saline-tolerant varieties, and improved drainage management for Kole fields.

Fig 4.11. 4th Samithi meeting in Thrissur

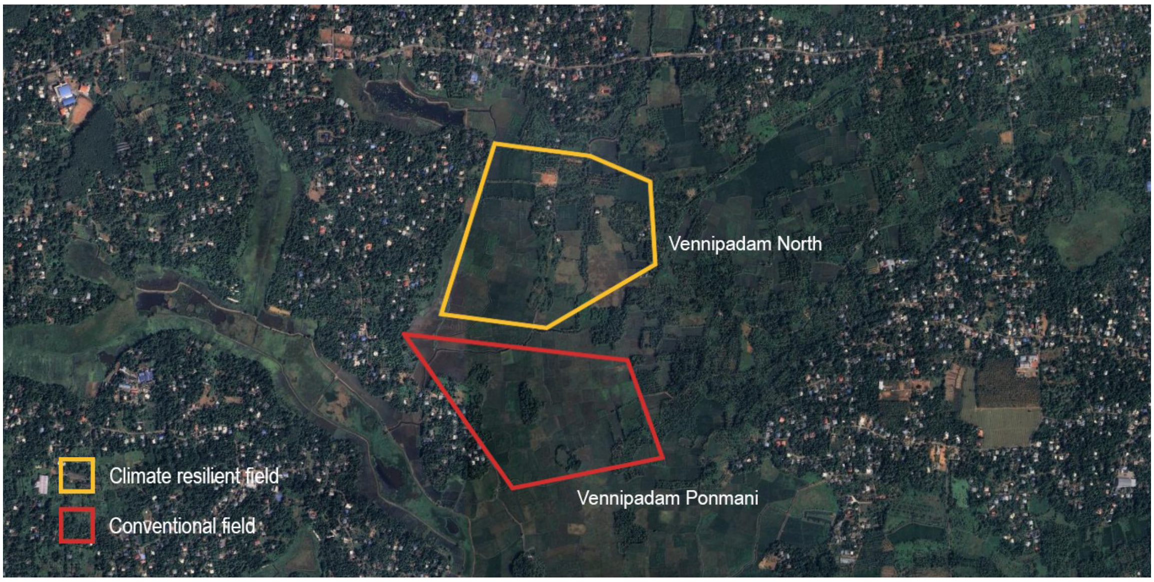


Fig 4.12. Selected Climate-Resilient and Conventional fields in Annamanada (Thrissur)

4.3.2. Cultivation Practices Implemented Across Study Districts

The field-level implementation of the climate-resilient rice farming protocol was undertaken in selected Padashekhara samithis, encompassing diverse rice-growing ecosystems such as below-sea-level polders, kole wetlands, and midland paddy fields. To facilitate a comprehensive comparative evaluation, both Climate-Resilient Samithis and Conventional Samithis were included in the study.

a - Climate-Resilient Fields

A total of 69 farmers participated in the climate-resilient cultivation system, collectively managing an area of 360.95 acres. The detailed distribution of the collaborated farmer groups is presented below.

Table 4.19. Summary of Climate-Resilient Samithis collaborated

District	Name of samithi	No. of land-owning farmers	No. of lease farmers	Area holding (acre)
Alappuzha	Rajaramapuram Kayal	4	5	114.50
Palakkad	Koorodmann	36	4	82.91
Kottayam	Kelakari Vattakayal, Ulakathanam & Kapponapuram	2	1	82.00
Thrissur	Vennipadam Vadakke Bhagam	8	9	81.54
Total		50	19	360.95

b - Conventional Fields

For comparative analysis, selected Conventional Samithis were identified in the study area to serve as a baseline for evaluating standard paddy cultivation practices. These farmer groups did not directly participate in the implementation of climate-resilient interventions but agreed to share detailed information regarding their cultivation activities. Data collection from the conventional fields included stage-wise management practices, input usage, cost components, and yield observations. The conventional Samithis permitted field-level sampling for carbon sequestration studies, allowing the assessment of soil organic carbon and biomass carbon levels in traditionally managed rice fields.

Table 4.20. The summary of Conventional fields monitored

District	Name of Conventional Samithi	Area holding (acre)
Alappuzha	24000 Kayal, E block	120.00
Palakkad	Vallakunnam Padashekhara Samithi	91.70
Kottayam	Akathekari Padashekhara Samithi	100.00
Thrissur	Vennipadam Ponmani Karshaka Sangham	70.00
Total		381.70

4.3.2.1 Cultivation Practices in Alappuzha District

I .Climate-Resilient Samithi: Rajaramapuram Kayal, Kavalam

In Rajaramapuram Kayal, the climate-resilient farming protocol was implemented as per the recommended guidelines. The interventions began with soil testing to determine field-specific nutrient requirements. Based on the soil test results, lime was applied during land preparation to correct soil acidity and improve nutrient availability. This was followed by mechanized sowing using a seed drum, which ensured uniform plant spacing and reduced seed wastage, contributing to better crop establishment.

Weed management was carried out in two stages. The first stage involved a pre-sowing weedicide application as part of the stale seed bed technique, a key recommendation in the climate-resilient protocol aimed at minimizing early weed pressure. The second stage involved a post-sowing application at 15 DAS to control emerging weeds during crop establishment. Fertilizer management followed a split application strategy, with customized dosages based on soil nutrient status. The first fertilizer application was completed in early December, followed by gap filling in late December to maintain optimal plant population. A leaf color chart (LCC) is used to assess the nitrogen status of the crop, based on which appropriate recommendations are provided to farmers for nitrogen management.

For pest management, Trichogramma cards (Trichocard) were introduced as part of a biological control strategy to reduce pesticide use. The application was repeated at 15-day intervals, with a total of four rounds, ensuring sustained pest management throughout the crop growth period. Additionally, Sampoorna, a balanced micronutrient mixture, was applied to improve crop vigor and resilience. The second and third fertilizer applications were completed in late December and mid-January, respectively. Harvesting was completed by mid-March 2025.

Table 4.21. Crop Calendar – Climate-Resilient Field

Sl. No	Activity	Date
1	Land Preparation	24/10/2024 – 14/11/2024
2	Sowing (Seed Drum Method)	14/11/2024 – 23/11/2024
3	Weedicide Application	04/11/2024 – 06/11/2024 (pre-sowing) 07/12/2024 (14 DAS)
4	First Fertilizer Application	02/12/2024 – 07/12/2024 (18–23 DAS)
5	Gap Filling	13/12/2024 – 28/12/2024 (29–44 DAS)
6	Trichocard Application	20/12/2024 – 24/12/2024 (36–40 DAS)
7	Sampoorna Application	16/01/2025 and 24/01/2025 (63 and 71 DAS)
8	Second Fertilizer Application	24/12/2024 – 27/12/2024 and 03/01/2025 (40–43 DAS)
9	Third Fertilizer Application	11/01/2025 – 18/01/2025 (58–65 DAS)
10	Harvest	15/03/25

Fig 4.13. Sowing using Seed Drum in Alappuzha

Fig 4.14. Distribution of Trichocard to Mr. K P Shaji

Fig 4.15. Distribution of Trichocard to Mr. Bijumon

Fig 4.16. Distribution of Trichocard to Mr. Bijumon PJ

Fig 4.17. Application of Trichocard

Fig 4.18. Use of LCC

Fig 4.19. Application of Sampoorna

Fig 4.20. Harvest

II. Conventional Samithi: 24,000 Kayal, E Block, Kavalam

In the conventional field at 24,000 Kayal, sowing was largely done through manual broadcasting. Fertilizer application was carried out without reference to soil test results, and micronutrient supplementation was not practiced. Pest, disease and weed management relied heavily on chemical applications, with no adoption of biological control methods. Overall cultivation activities followed conventional farming practices without field-specific adjustments. Harvesting in these fields was completed by mid-March 2025.

Table 4.22. Crop Calendar – Conventional Field

Sl. No	Activity	Date
1	Land Preparation	04/11/2024 – 25/11/2024
2	Sowing	25/11/2024
3	Weedicide Application	12/12/2024 (17 DAS)
4	First Fertilizer Application	15/12/2024 (20 DAS)
5	Gap Filling	27/12/2024 (32 DAS)
6	Second Fertilizer Application	04/01/2025 (40 DAS)
7	Third Fertilizer Application	30/01/2025 (66 DAS)
8	Harvest	16/03/25 (111 DAS)

4.3.2.2 Cultivation Practices in Palakkad District

I. Climate-Resilient Samithi: Koorodmannu Padashekhara Samithi, Alathur

In Koorodmannu Padashekhara Samithi, nursery sowing was completed in mid-November, followed by machine transplanting in the last week of November and the first week of December. This method ensured uniform planting, reduced seedling damage, and minimized labor requirements. As part of soil management, lime application was carried out during land preparation to correct soil acidity, based on soil test recommendations. Weed management was initiated in the third week after transplanting, using targeted herbicide application aligned with the crop's early growth stage. Fertilizer management followed a split-application schedule, starting with the first dose in the early vegetative phase, as per soil test-based recommendations.

For pest management, Trichocards were introduced at around 33 DAS, and replacements were made four times at 15-day intervals. This continuous biological control strategy reduced chemical pesticide dependency and supported ecological sustainability in the field. The leaf color chart was utilized to monitor the crop's nitrogen levels, and guidance on nitrogen application was provided to farmers accordingly.

The second fertilizer application was conducted in the mid-vegetative phase, followed by a micronutrient mix combined with the third fertilizer dose in the late vegetative to early reproductive stage. These interventions contributed to enhanced plant vigor and improved resilience to climatic stresses.

Harvesting was completed in mid-March 2025, marking the completion of the climate-resilient paddy cultivation cycle in Palakkad.

Table 4.23. Crop Calendar – Climate-Resilient Field

Sl No	Activity	Date
1.	Land preparation	30/10/24-15/11/24
2.	Nursery sowing	15/11/24
3.	Transplantation	27/11/24-09/12/24 (12-24 DAS)
4.	Weedicide application	06/12/24-09/12/24 (21 DAP-24 DAP)
5.	First fertiliser application	06/12/24-18/12/24 (21 DAP-33 DAP)
6.	First trichocard application	18/12/24-25/12/24 (33 DAP-40 DAP)
7.	Second fertiliser application	02/01/25-08/01/25 (48 DAP-54 DAP)
8.	Micronutrient mix application along with third fertiliser	26/01/25 (72 DAP)
9.	Harvest	14/03/25 (119 DAS)

Fig 4.21. Nursery preparation

Fig 4.22. Machine Transplantation

Fig 4.23. Application of Trichocard

Fig 4.24. Use of LCC

Fig 4.25. Application of Fertilizer mix using Drone

Fig 4.26. Harvest

II. Conventional Samithi: Vallakkunnam Padashekhara Samithi, Alathur

The conventional field in Vallakkunnam Padashekhara Samithi followed traditional paddy farming practices. Sowing was done using a combination of broadcasting and manual transplanting, with field operations largely dependent on manual labor. Fertilizer was applied without soil testing, and pest, disease and weed management involved heavy use of chemicals. Harvesting was completed by March 2025

Table 4.24. Crop Calendar – Conventional Field

Sl No	Activity	Date
1.	Land preparation	30/10/24-12/11/24
2.	Nursery sowing	12/11/24
3.	Transplantation	29/11/24 (17 DAS)
4.	Weedicide application	04/12/24 (5 DAP)
5.	First fertiliser application	22/12/24 (23 DAP)
6.	Pesticide application	24/12/25 (25 DAP)
7.	Second fertiliser application	08/01/25 (40 DAS)
8.	Third fertiliser application	07/02/25 (70 DAS)
9.	Harvest	20/03/25 (111 DAS)

4.3.2.3. Cultivation Practices in Thrissur District

I. Climate-Resilient Samithi: Vennipadam Vadakke Bhagam Nellulpadaka Karshaka Samithi, Annamanada

In Vennipadam Vadakke Bhagam, the climate-resilient farming protocol was implemented with sowing and transplanting scheduled to accommodate field-level variability. Nursery sowing was conducted in batches during October and November, followed by transplanting operations in November and December. Lime application was carried out during land preparation, as per soil test recommendations, to correct soil acidity

Weed management was performed using targeted herbicide application between 11 and 15 DAP. Fertilizer management followed a split-application strategy based on soil test result, with the first fertilizer dose applied in the early vegetative stage, adjusted according to field conditions.

For pest management, Trichocard were introduced at 38 DAS as a biological control measure. The second fertilizer application was carried out in the mid-vegetative phase, and the third application was completed during the late vegetative to early reproductive stage. Nitrogen status in the crop was assessed using a leaf color chart, helping farmers adjust nitrogen application based on real-time field conditions. These nutrient management strategies were aimed at improving plant health, enhancing grain formation, and building resilience against climatic stress. In the Thrissur Samithi, untimely rainfall during the early stages of cultivation led to the loss of seedlings, forcing farmers to replant the crop. This replanting resulted in an overall delay in the crop cycle. Additionally, the variety cultivated in this region was a long-duration paddy variety 'Ponmani' with a growth period of 160 days. Harvesting was completed during the second half of April 2025, marking the conclusion of the climate-resilient cultivation cycle in Thrissur.

Table 4.25. Crop Calendar – Climate-Resilient Field

Sl. No	Activity	Date
1	Land Preparation	24/09/2024 – 06/10/2024
2	Nursery Sowing	06/10/2024, 15/10/2024, 15/11/2024 – 30/11/2024
3	Transplantation	01/11/2024, 16/11/2024, 18/12/2024 – 30/12/2024
4	Weedicide Application	29/12/2024, 02/01/2025 (11–15 DAP)
5	First Fertilizer Application	22/11/2024, 23/11/2024, 04/01/2025 – 08/01/2025 (21 DAP)
6	Trichocard Application	23/12/2024 (38 DAS)(Repeated every 15 days, total 4 rounds)
7	Second Fertilizer Application	13/12/2024, 15/12/2024, 13/01/2025 – 27/01/2025 (44–58 DAP)
8	Third Fertilizer Application	19/01/2025, 03/02/2025, 11/02/2025, 14/02/2025, 16/02/2025 (74–85 DAP)
9	Harvest	15/04/2025 – 20/04/2025 (160 DAS-165 DAS)

Fig 4.27. Liming

Fig 4.28. Nursery

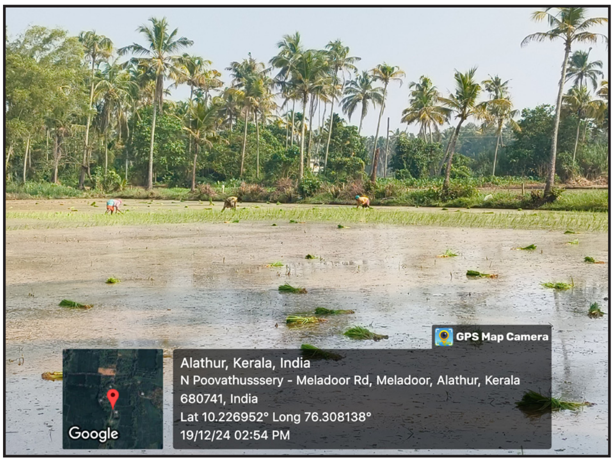


Fig 4.29. Transplanting

Fig 4.30. Distribution of Trichocard to Mr. Sunil

Fig 4.31. Distribution of Trichocard to Mr. Rajan

Fig 4.32. Application of Trichocard

Fig 4.33. Use of LCC

Fig 4.34. Harvest

II. Conventional Samithi: Vennipadam Ponmani Karshaka Sangham, Annamanada

In Vennipadam Ponmani, field operations were carried out using conventional farming methods. Sowing and transplanting were done manually, and pest control relied on chemical pesticide applications. Fertilizers were applied without soil test-based recommendations, and micronutrient management was not practiced. Harvesting took place in mid-May 2025.

Table 4.26. Crop Calendar – Conventional Field

Sl. No	Activity	Date
1	Land Preparation	24/09/2024 – 06/10/2024
2	Nursery Sowing	06/12/2024
3	Transplantation	03/01/2025
4	Weedicide Application	29/01/2025 (26 DAP)
5	First Fertilizer Application	03/01/2025 (During Transplantation)
6	Second Fertilizer Application	03/02/2025 (30 DAP)
7	Third Fertilizer Application	04/03/2025 (61 DAP)
8	Harvest	14/05/2025

4.3.2.4. Cultivation Practices in Kottayam District

I. Climate-Resilient Samithis: Kelakari Vattakkayal, Kumarakom & Ulakathanam Padashekhara Samithi, Changanassery.

In Kottayam, the climate-resilient rice farming protocol was implemented in two locations: Kelakari Vattakkayal in Kumarakom and Kapponapuram Padashekhara Samithi in Changanassery.

In Kelakari Vattakkayal, sowing was conducted in the last week of December, following standard land preparation procedures. Weed management involved herbicide applications during the second week of January, targeting early-stage weed control. The first fertilizer application was carried out at 21 DAS, synchronized with the introduction of Trichocard for biological pest control. The second fertiliser application was completed in mid February.

In Ulakathanam Padashekhara Samithi, lime was applied during land preparation, as per recommendations, to correct soil acidity. Sowing began in the third week of December, followed by weedicide applications in the second week of January. Trichocard application commenced at 15 DAS and was maintained to reduce pest pressure without reliance on chemical pesticides. The leaf color chart was used to guide farmers on nitrogen application based on crop condition. Gap filling was performed at 33 DAS to ensure uniform plant population, followed by the first and second fertilizer applications in late January and early February, respectively. A micronutrient mix (Sampoorna) was applied at 53 DAS to enhance crop vigor and grain quality.

Harvesting was completed by early April in Kelakari Vattakkayal and by late April in Kapponapuram, marking the conclusion of climate-resilient cultivation cycles in Kottayam.

Table 4.27. Crop Calendar – Climate-Resilient Fields

Sl. No	Activity	Kelakari Vattakkayal, Kumarakom	Ulakathanam Padashekhara Samithi, Changanassery
1	Land Preparation	2 weeks before sowing	3 weeks before sowing
2	Sowing	25/12/2024	23/12/2024
3	Weedicide Application	10/01/2025 – 13/01/2025 (16–19 DAS)	07/01/2025 – 09/01/2025 (15–17 DAS)
4	Trichocard Application	15/01/2025 (21 DAS)	09/01/2025 (15 DAS)
5	Gap Filling	—	25/01/2025 (33 DAS)
6	First Fertilizer Application	15/01/2025 (21 DAS)	20/01/2025, 29/01/2025 (28 & 37 DAS)
7	Second Fertilizer Application	12/02/2025 – 17/02/2025 (49–54 DAS)	08/02/2025 – 10/02/2025 (47–49 DAS)
8	Sampoorna Micronutrient Application	—	14/02/2025 (53 DAS)
9	Harvest	08/04/2025 (104 DAS)	22/04/2025 (120 DAS)

Fig 4.35. Land Preparation

Fig 4.36. Sowing using Seed drum

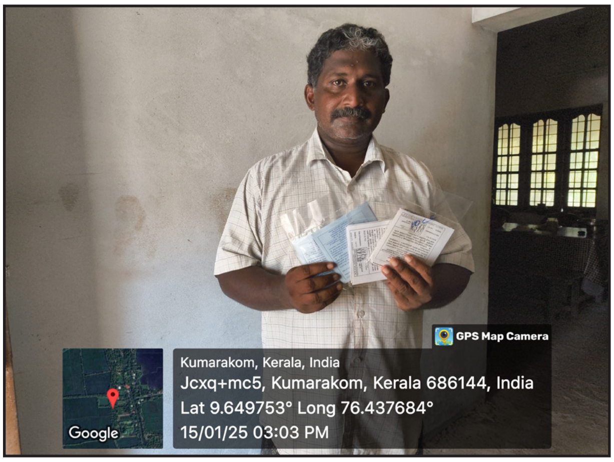


Fig 4.37. Distribution of Trichocard to Mr. Jomon

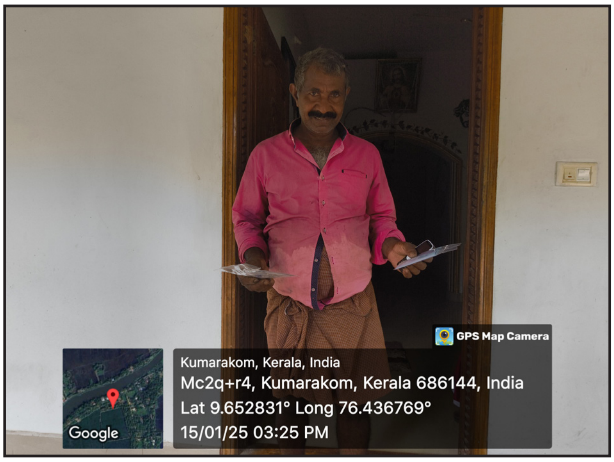


Fig 4.38. Distribution of Trichocard to Mr. Sabu

Fig 4.39. Distribution of Trichocard to Mr. Thomas

Fig 4.40. Application of Trichocard

Fig 4.41. Use of LCC

Fig 4.42. Harvest

II. Conventional Samithis: Akathekari Padashekhara Samithi, Kumarakom & Poovath Thollayiram Kizhakku Padashekhara Nellulpadaka Samithi, Changanassery

In Kottayam's conventional fields, cultivation was carried out using traditional methods without the adoption of climate-resilient interventions. Both Akathekari Padashekhara Samithi in Kumarakom and Poovath Thollayiram Kizhakku Padashekhara Samithi in Changanassery followed conventional farming practices. Harvesting in Akathekari was completed in late April, while in Poovath Thollayiram, harvesting was done earlier, in March 2025.

Table 4.28. Crop Calendar – Conventional Fields

Sl. No	Activity	Akathekari, Kumarakom	Poovath Thollayiram, Changanassery
1	Land Preparation	2 weeks before sowing	3 weeks before sowing
2	Sowing	17/12/2024	30/11/2024
3	Weedicide Application	02/01/2025 (16 DAS)	16/12/2024 (16 DAS)
4	First Fertilizer Application	03/01/2025 (17 DAS)	18/12/2024 (18 DAS)
5	Second Fertilizer Application	21/01/2025 (35 DAS)	17/01/2025 (48 DAS)
6	Third Fertilizer Application	01/02/2025 (46 DAS)	—
7	Micronutrient Application	—	30/01/2025 (61 DAS)
8	Harvest	22/04/2025 (126 DAS)	22/03/2025 (112 DAS)

4.3.3. Constraints During Implementation

The implementation phase of the climate-resilient paddy cultivation project encountered several operational and behavioral challenges that affected the extent of practice adoption and field-level outcomes. While the project aimed to introduce sustainable and adaptive farming practices, real-world constraints at the farmer and community levels posed considerable hurdles. These constraints can be broadly categorized into social, logistical, technological, and financial barriers, as detailed below.

4.3.3.1. Input Procurement and Accessibility Challenges

Procurement-related issues further compounded the problem. The availability of key agricultural tools and inputs necessary for implementing improved practices was highly restricted. The helical puddler, recommended for effective puddling and land preparation, was not readily available in most locations. Even where available, the cost of using the helical puddler was prohibitively high for small and marginal farmers. This was due to a combination of factors including expensive rental charges, high transportation costs to move the equipment to remote fields, and the need to pay additional labour charges to the operator. These cumulative expenses made it difficult for farmers to incorporate mechanized land preparation into their routine practices. Similarly, the use of seed drums, promoted for line sowing and optimal seed rate management, was constrained by limited availability. Seed drums are costly to purchase, and the number of units available for rental through Krishi Bhavans, KVKs, or fellow farmers was insufficient to meet demand. Moreover, traditional farmers were reluctant to adopt this technology due to their entrenched preference for broadcasting, which uses a higher seed rate. The perception that higher seed density ensures better crop establishment remained a barrier to change.

The availability of biological control agents such as Trichocard was also limited. Farmers could access Trichocard only from Kerala Agricultural University (KAU) and Parasite Breeding Stations (PBS), making it inaccessible to many, especially those in remote locations. Furthermore, the quality of Trichocard procured from PBS Kalarcode was reported to be poor, leading to a lack of confidence among farmers regarding its effectiveness. In addition to supply and quality issues, the effectiveness of Trichocard was often compromised by chemical pesticide applications in adjacent fields, which led to the destruction of parasitoids released for pest control. As a result, several farmers refused to adopt biological control methods, citing concerns over neighboring farms' continued use of chemical pesticides, which undermined the impact of Trichocard applications.

4.3.3.2. Field-Level Challenges in Water Management

Field-level challenges were also significant, especially in water management. Alternate Wetting and Drying (AWD), a recommended practice for reducing water use and controlling greenhouse gas emissions, could not be implemented effectively. In many Padasekharam regions, farmers do not have individual control over irrigation. Water management is often collective, making it difficult to synchronize drying periods across adjacent fields. Additionally, the lack of proper infrastructure to regulate and monitor water levels further restricted the adoption of AWD practices.

4.3.3.3. Resistance to Technological Shifts

Farmers' hesitation to embrace new technologies was another critical constraint. Many traditional farmers were cautious about shifting from familiar methods to climate-resilient alternatives. This was evident not only in their reluctance to adopt seed drum sowing but also in their unwillingness to apply micronutrient mixtures such as Sampoorna. Despite its proven benefits in improving rice productivity by addressing micronutrient deficiencies, farmers lacked adequate awareness about Sampoorna and continued to rely solely on NPK fertilizers.

4.3.3.4. Poor Uptake of Crop Insurance Schemes

Another area of concern was the poor uptake of central government crop insurance schemes. Farmers cited high premium costs as a major deterrent. Many of them are already burdened with debts and find it difficult to allocate additional funds for insurance payments. Furthermore, past experiences with delayed or denied claims have eroded their trust in the insurance system. As a result, most farmers chose not to enroll, perceiving it as an additional expense that offered little return.

4.3.3.5. Lack of Skilled Labour

Skilled labour was especially needed for lime and dolomite application, which require precise timing and even field distribution. Improper application by untrained workers reduced effectiveness and discouraged farmers from adopting the practice.

4.3.3.6. Lack of Farmer Cooperation

One of the primary issues encountered was the lack of full cooperation from farmers. Since the project did not provide direct input support—such as seeds, fertilizers, or biocontrol agents—many farmers, especially those facing financial constraints, were hesitant to fully adopt the recommended practices. In such contexts, the absence of material assistance often becomes a critical barrier to participation in new interventions. In addition, a general lack of cooperation among farmers emerged as a significant challenge. This was influenced by multiple factors, including fragmented landholdings, lack of collective decision-making mechanisms, trust deficits, and differences in resource capacities, all of which limited coordinated action and joint implementation of climate-resilient practices.

To address these structural challenges and foster collective resilience, TIES has initiated the formation of TIES Farmer Producing Company Limited (TIES FPC Ltd.), with support from NABARD. The FPC is envisioned as a farmer-led platform to revitalize fallow lands, provide access to scientific farming support, secure inputs and mechanization services, and strengthen market linkages. Through this initiative, farmers are empowered to engage in sustainable agriculture while improving their bargaining power and creating new livelihood opportunities, including for rural youth.

4.3.4. Field-Level Project Monitoring

A structured and continuous monitoring system was established to ensure that the climate-resilient paddy cultivation protocols were implemented effectively across the selected fields. Monitoring activities were carried out throughout the agricultural season, covering all key stages from land preparation to harvest and post-harvest operations. The objectives were to identify field-level challenges, provide timely guidance and support to farmers based on the specific problems observed in the field, assess the extent of adoption of climate-resilient practices, and document each stage of crop management and variations between climate-resilient and conventional farming systems.

4.3.4.1 Field Visits

Periodic field visits were conducted by the project team in collaboration with Padasekhara Samithi representatives and agricultural extension personnel. During these visits, detailed observations were made regarding crop conditions, input usage, pest and disease occurrence, water management, labour deployment, and each practice was documented. The visits also ensured that farmers were adhering to the prescribed protocols. In cases where deviations from the suggested practices were observed, the reasons were carefully documented through direct farmer interactions.

Fig.4.43. Field visit at Kavalam, Alappuzha

Fig.4.44. Field visit at Changanassery, Kottayam

Fig.4.45. Field visit at Alathur, Palakkad

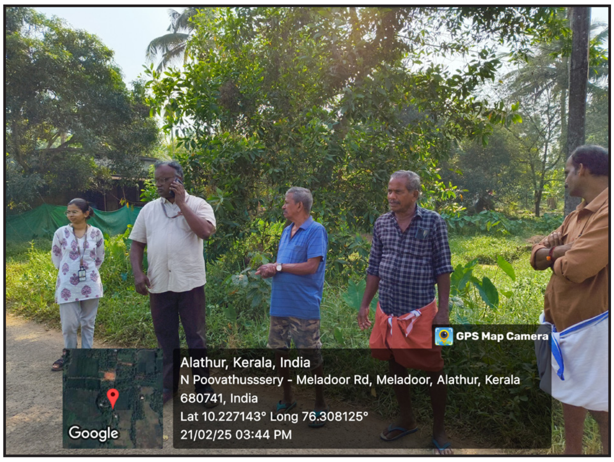


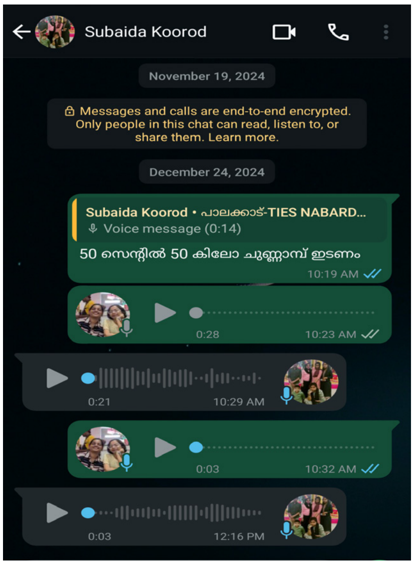
Fig.4.46. Field visit at Annamanada, Thrissur

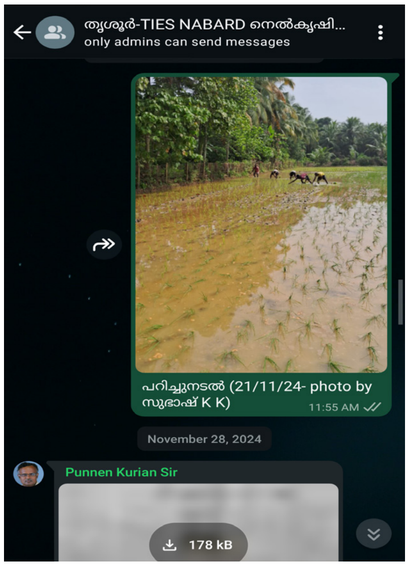
4.3.4.2 Telephonic Calls

In addition to physical field visits, telephonic interviews were conducted with farmers at periodic intervals to collect real-time data on the agricultural operations carried out in each plot. These calls focused on recording the specific agricultural practices followed at different crop stages, noting the types and quantities of inputs used, and tracking the labour and operational costs incurred by the farmers. The telephonic monitoring approach ensured that detailed input-output records were maintained without causing interruptions to farmers' routine activities. Data on seed rates, fertilizer application (both organic and chemical), pesticide usage, irrigation events, and harvesting methods were captured systematically through these interviews.

4.3.4.3 WhatsApp Groups

Digital communication platforms such as WhatsApp groups were also used for disseminating advisories, and providing pest and disease management guidance. Farmers were encouraged to report emerging issues through these channels, allowing the technical team to provide timely support and field-level problem-solving (Appendix XI).





4.3.4.4 Project Management Committee Meetings

Project Management Committee meetings were held to review field observations and data collected through visits, telephonic monitoring, and digital communications. One meeting was conducted before the start of the project to plan activities and finalize implementation strategies. Another meeting was held after project implementation to discuss progress, analyze field-level challenges, and decide on corrective actions to support farmers and ensure the smooth implementation of the climate-resilient farming protocols.

4.3.5. Assessment of Compliance with the Climate-Resilient Paddy Farming Protocol

The adoption of the Climate-Resilient Paddy Farming Protocol was assessed using a structured scorecard system to measure compliance levels across both climate-resilient and conventional Samithis. The evaluation captured the extent to which recommended practices related to input management, water use efficiency, pest control, soil health management, and post-harvest care were implemented at the field level.

4.3.5.1 District-Wise Protocol Adherence

The table below presents the percentage of adherence to the protocol in each district for both climate-resilient and conventional Samithis:

Table 4.29. District-wise assessment of protocol adherence in Climate-Resilient and Conventional Samithis

Districts	Climate-Resilient Samithi(%)	Conventional Samithi(%)
Alappuzha	53	26
Palakkad	57	24
Thrissur	50	23
Kottayam	55	17

The results clearly demonstrate a consistent pattern of higher adherence to the recommended practices in the climate-resilient Samithis across all four districts. Notably, each climate-resilient field recorded more than 50% compliance, indicating that the protocol was not only well-received by farmers but also feasible for implementation under real-world field conditions. Palakkad showed the highest level of adherence at 57%, followed by Kottayam (55%), Alappuzha (53%), and Thrissur (50%). This uniformity across districts with varying agro-ecological conditions reflects the protocol's adaptability and practical relevance.

The high compliance levels observed suggest that the structured support system—comprising digital communication tools like WhatsApp groups, regular field visits, and participatory engagement—played a crucial role in reinforcing farmer confidence and encouraging adoption. These mechanisms enabled timely dissemination of technical advice and problem-solving support, contributing significantly to the successful implementation of the protocol.

The analysis also highlighted that the average adherence in conventional fields was 23%, representing the mean compliance rate across the conventional Samithis in all four districts. This level of adherence is not attributed to the adoption of the climate-resilient protocol—since no new interventions were introduced in these fields—but rather reflects the continuation of certain good traditional practices. Many of these indigenous methods naturally align with climate-resilient principles, indicating that traditional knowledge still plays a role in promoting sustainability at the grassroots level.

4.3.5.2 Sub-Component Analysis: Pest Management, Weed Management, and Insurance Uptake

In addition to the overall protocol adherence, specific sub-components of the climate-resilient protocol were analyzed to understand adoption patterns in critical operational areas such as pest management, weed management, and crop insurance utilization.

I. Pest Management Adherence

The percentage of farmers following the recommended pest management methods is summarized below:

Table 4.30. Adherence to recommended pest management practices in Climate-Resilient Samithis

Districts	Pest Management Adoption (%)
Palakkad	59
Alappuzha	61
Thrissur	41
Kottayam	67

The data shows that Kottayam recorded the highest adherence to the recommended pest management practices at 67%, followed by Alappuzha (61%) and Palakkad (59%). Thrissur reported the lowest adherence at 41%.

In most climate-resilient fields, farmers implemented biocontrol-based pest management as prescribed in the protocol. However, the lack of synchronized pest management in neighbouring conventional fields led to increased pest pressure due to migration from adjacent plots. This situation particularly affected Thrissur, where farmers had to resort to additional chemical pesticide applications beyond the protocol recommendations to manage severe pest outbreaks. This highlights the challenges of implementing ecological pest management in isolated fields without wider community-level coordination.

II. Weed Management Adherence

The adherence to recommended weed management practices was as follows:

Table 4.31. Adherence to recommended weed management practices in Climate-Resilient Samithis

Districts	Weed Management Adoption (%)
Palakkad	70
Alappuzha	51
Thrissur	32
Kottayam	27

Weed management practices showed variable adoption across the districts. Palakkad recorded the highest adherence at 70%, followed by Alappuzha at 51%. Thrissur and Kottayam reported lower compliance levels, with 32% and 27% adoption, respectively.

In Thrissur, the lower adherence was primarily linked to issues with seed quality in the variety sown, which led to poor crop establishment and increased weed proliferation. Despite farmers' willingness to implement the recommended practices, managing weeds under such conditions required additional effort and resources.

In Kottayam, saltwater intrusion into the fields posed a significant challenge to effective weed control. The resulting saline stress reduced crop competitiveness, making weed management more demanding despite the prescribed interventions.

III. Crop Insurance Uptake

The percentage of farmers who availed crop insurance under the climate-resilient protocol is presented below:

Table 4.32. Crop insurance uptake among farmers in Climate-Resilient Samithis

Districts	Insurance Uptake (%)
Palakkad	74
Alappuzha	56
Thrissur	74
Kottayam	17

Palakkad and Thrissur recorded the highest insurance uptake at 74%, reflecting greater awareness of risk mitigation measures and willingness to adopt financial safety nets. Alappuzha reported moderate uptake at 56%, while Kottayam lagged significantly behind at 17%.

This disparity is not solely due to differences in awareness but is also linked to practical concerns regarding the insurance scheme's implementation at the local level. In several regions, farmers expressed hesitation to enroll in crop insurance due to inconsistent disbursement of compensation and perceived delays in claim settlements.

Moreover, the requirement that farmers must incur at least 75% crop loss to become eligible for compensation discourages participation. Many farmers also highlighted that they are unable to harvest partially salvageable crops if they wish to claim insurance, leading to a dilemma between attempting recovery of yield and pursuing compensation. These constraints have limited insurance uptake in certain areas, particularly in Kottayam.

4.3.5.3. Insights on Protocol Adoption

The assessment of compliance with the Climate-Resilient Paddy Farming Protocol across the four study districts revealed encouraging levels of adoption, particularly in the climate-resilient Samithis where protocol adherence consistently exceeded 50%. This underscores the practical feasibility and farmer receptiveness towards sustainable farming practices when supported through structured engagement, advisory services, and real-time communication. The participatory approach, combined with regular field monitoring and digital communication platforms, played a pivotal role in strengthening adoption and translating recommendations into actionable field practices.

The average adherence in conventional fields was recorded at 23%. This compliance is not the result of adopting the newly introduced climate-resilient protocol, as no such interventions were implemented in these Samithis. Instead, it reflects the continuation of certain traditional farming practices that inherently support resilience. Many of these customary methods coincide with the recommended climate-resilient practices, providing a valuable baseline for future interventions and offering a pathway for smoother integration of improved sustainable practices.

The sub-component analysis offered deeper insights into specific areas of protocol implementation. While pest management practices were largely adopted, challenges such as pest migration from neighboring conventional fields led to additional pesticide use in certain locations, particularly in Thrissur. Weed management showed district-level variations, influenced by factors like seed quality and saline stress due to saltwater intrusion, which affected crop vigor and increased weed infestation in some regions. Insurance uptake also varied significantly, with higher participation in Palakkad and Thrissur but notably low enrollment in Kottayam, primarily due to procedural concerns such as delayed compensation and the stringent requirement of proving a 75% crop loss.

Overall, the findings demonstrate that the climate-resilient farming protocol is implementable across Kerala's varied rice-growing regions, with farmers showing encouraging levels of adherence. At the same time, the analysis highlights certain practical factors that influenced adoption in specific components. Community-level coordination in pest management, better seed quality assurance, strategies to manage saline-prone fields, and streamlining crop insurance processes can further support farmers in adopting the full range of recommended practices. Addressing these aspects will help improve uniformity in adherence and strengthen the long-term sustainability of climate-resilient rice farming in the state.

4.3.6. Evaluation of Climate Resilient Paddy Cultivation Protocol During Puncha/Second Crop Season

4.3.6.1. Reduced Toxicity Index (RTI)

I. District wise analysis on Reduced Toxicity Index

a. Palakkad

Table 4.33. Reduced toxicity index of Palakkad (Values are Mean ± SD)

Sub indices	Climate resilient	Conventional
Type of Chemical used	2.41 ± 0.35	2.38 ± 0.31
Frequency of application	1.39 ± 0.26	1.50 ± 0.00
Stage of crop growth at application	1.39 ± 0.19	1.38 ± 0.14
Dosage per application	1.42 ± 0.26	1.51 ± 0.22
Environmental pollution possibilities	0.75 ± 0.75	0.50 ± 0.00
Index value	7.40 ± 0.71	7.30 ± 0.52

Palakkad recorded the highest RTI values of 7.4 for climate resilient fields and 7.3 for conventional fields (Table 4.33), indicating the most significant overall reduction in environmental toxicity. This positive outcome is largely attributable to the improved agronomic practices introduced as part of the climate-resilient paddy farming protocol, along with the fact that many farmers in the region were already following relatively better farming practices prior to the intervention. These practices, including fertilizer and lime application based on soil testing, machine transplantation, micronutrient mix application, use of biocontrol agents for plant protection, and optimized use of chemical inputs, have promoted a healthier and more vigorous crop stand in the climate resilient fields. As a result, these fields exhibit greater resilience to biotic and abiotic stresses, reducing the need for chemical interventions and contributing to a higher reduction in toxicity levels.

In both farming systems, most farmers reported the use of less hazardous weedicides, typically applied during the early stages of crop growth and generally at recommended or reduced dosages, contributing to lower toxicity levels. The slightly higher RTI observed in climate-resilient fields is attributed to targeted interventions introduced through the project, including access to subsidized biocontrol agent (Tricho card) via Krishibhavans, adherence to safe application practices and precise input management.

Additionally, climate-resilient fields utilize machine transplantation, which enables better plant spacing and reduces the incidence of pest, weeds, and disease and chemical inputs compared to the manual transplanting and broadcasting methods commonly employed in conventional fields. Although several elements of the climate-resilient protocol were already being informally adopted in the region—resulting in relatively similar RTI values in conventional fields—the absence of biocontrol agent application in conventional fields often led to a heavier reliance on repeated chemical applications for pest control, thereby limiting their overall potential for toxicity reduction.

Palakkad's high Reduced Toxicity Index is shaped by its unique combination of agro-climatic and socio-economic conditions. Moderate pest and weed pressure due to favorable weather, coupled with widespread farmer awareness and early adoption of eco-friendly practices, has enabled more responsible chemical use. The district's well-developed extension network and proactive use of biocontrol agents further reduce dependency on hazardous inputs, supporting a farming environment that naturally promotes lower environmental toxicity.

b. Alappuzha

Table 4.34. Reduced toxicity index of Alappuzha (Values are Mean ± SD)

Sub indices	Climate resilient	Conventional
Type of Chemical used	2.41 ± 0.39	2.48 ± 0.25
Frequency of application	1.17 ± 0.26	1.08 ± 0.20
Stage of crop growth at application	1.25 ± 0.23	1.29 ± 0.11
Dosage per application	1.54 ± 0.36	1.17 ± 0.33
Environmental pollution possibilities	0.25 ± 0	0.25 ± 0.00
Index value	6.60 ± 0.42	6.30 ± 0.50

Alappuzha reported the lowest RTI values among the districts, with 6.6 for climate-resilient fields and 6.3 for conventional fields (Table 4.34), indicating consistently lower toxicity reduction across both farming systems. This is partly due to the higher number of chemical applications in both systems, driven by persistent pest and disease pressure under high-moisture conditions typical of the district's coastal wetland environment. Despite these challenges, climate-resilient fields demonstrated a modest advantage in toxicity reduction through the use of less hazardous chemicals, greater reliance on biocontrol agents, and timely application of inputs at recommended doses, especially during early crop growth stages.

A key practice in climate-resilient fields is sowing with seed drums, which improves plant spacing, tillering and aeration. This reduces weed growth and lowers pest and disease incidence, decreasing the need for chemical interventions and helping to limit toxicity levels.

The unique coastal landscape of Alappuzha—with its wetlands and interconnected water bodies—requires careful chemical management to prevent runoff and protect fragile ecosystems. Despite intensive cultivation, the adoption of safer inputs, seed drum sowing, and integrated pest management contribute to enhanced sustainability in paddy farming.

Alappuzha's low RTI values reflect the challenges posed by its unique agro-ecological settings, and high humidity that fosters persistent pest pressure. These conditions often necessitate more frequent chemical applications. However, the district's growing awareness of ecological risks, and gradual adoption of mechanisation and integrated pest management practices have supported safer input use in climate-resilient fields. While toxicity reduction is modest, Alappuzha's landscape and socio-economic structure offer a foundation for improving sustainability through more targeted interventions.

c. Kottayam

Table 4.35. Reduced Toxicity Index of Kottayam (Values are Mean ± SD)

Sub indices	Climate resilient	Conventional
Type of Chemical used	2.31 ± 0.34	2.28 ± 0.46
Frequency of application	1.17 ± 0.29	1.33 ± 0.29
Stage of crop growth at application	1.22 ± 0.26	1.39 ± 0.24
Dosage per application	1.42 ± 0.38	1.48 ± 0.33
Environmental pollution possibilities	0.58 ± 0.29	0.25 ± 0.00
Index value	6.70 ± 1.27	6.70 ± 0.39

Kottayam recorded identical RTI values of 6.7 in both climate-resilient and conventional fields (Table 4.35), indicating minimal difference in toxicity reduction between the two systems. In climate-resilient fields, improved pest management practices were adopted, including the use of less hazardous chemicals at recommended or reduced dosages, along with the application of biocontrol agents such as Trichogramma spp. (TrichoCard) to reduce chemical reliance. However, a significant challenge was the influence of conventional farming in adjacent fields, where frequent chemical use led to drift and cross-contamination, reducing the efficacy of biocontrol efforts and necessitating additional chemical applications. Furthermore, extended periods of cloudy weather during the study reduced the activity of Trichogramma agents, limiting pest suppression effectiveness, which also increased the chemical need. In addition, the quality of TrichoCard was low, as it was sourced from the Parasite Breeding Station in Kalarcode, Alappuzha, further diminishing its impact on pest control.

Kottayam's agro-climatic and geographical characteristics such as its low-lying wetland ecosystem, frequent water stagnation, salt water intrusion and high humidity—create conditions highly conducive to pest and weed growth. Given its location in the Kuttanad region, where such pressures are particularly intense, chemical control remains a dominant practice. Despite efforts to implement climate-resilient practices, a combination of environmental, geographical, and operational factors continues to sustain higher toxicity levels in both farming systems.

d. Thrissur

Table 4.36. Reduced toxicity index (RTI) of Thrissur (Values are Mean ± SD)

Sub indices	Climate resilient	Conventional
Type of Chemical used	2.39 ± 0.47	2.07 ± 0.25
Frequency of application	1.46 ± 0.26	1.2 ± 0.27
Stage of crop growth at application	1.53 ± 0.18	1.26 ± 0.07
Dosage per application	1.67 ± 0.20	1.58 ± 0.24
Environmental pollution possibilities	0.25 ± 0.00	0.75 ± 0.00
Index value	7.30 ± 0.80	6.90 ± 0.31

Thrissur showed a clear distinction between the two farming systems, with climate-resilient fields achieving a higher RTI of 7.3 compared to 6.9 in conventional fields—the largest gap observed among the districts (Table 4.36). This suggests that climate-resilient practices in the region have a significant effect on lowering environmental toxicity. The improved outcomes in these fields can be credited to key interventions such as the use of less hazardous chemicals, reliance on biocontrol agents for pest management, and reduced frequency of chemical applications. Additionally, the timing of treatments is optimized—mainly during early crop stages—maximizing effectiveness while minimizing harm. Careful adherence to recommended or reduced dosages also ensures efficient use of inputs and limits toxic buildup in the ecosystem.

Thrissur's paddy ecosystems span kole wetlands, midlands, and uplands, offering ecological diversity but also posing significant challenges for rice cultivation. Issues like frequent waterlogging in kole lands, uneven terrain, and varying pest pressures complicate field operations. The climate-resilient protocol was particularly relevant here, as it allowed for site-specific input planning, better timing of interventions, and reduced dependency on chemical controls.

II. Comparative Analysis of RTI of Climate-Resilient and Conventional Paddy Cultivation in Kerala

Table 4.37. Reduced toxicity index values of Climate- Resilient and Conventional paddy cultivation (Values are Mean ± SD)

District	Climate resilient	Conventional
Alappuzha	6.6 ± 0.4	6.3 ± 0.5
Kottayam	6.7 ± 1.3	6.7 ± 0.4
Palakkad	7.4 ± 0.7	7.3 ± 0.5
Thrissur	7.3 ± 0.8	6.9 ± 0.3

Climate-resilient fields achieved higher RTI scores by prioritizing biologically and environmentally safer alternatives. Biopesticides like Pseudomonas fluorescens were used for seed treatment, while Trichocards containing Trichogramma japonicum and Trichogramma chilonis were deployed for biological control of pests such as stem borers and leaf folders. When chemicals were used, they were selected from low-toxicity categories and applied only at recommended doses during early vegetative stages to minimize residual risks. Spraying was carefully managed to prevent drift near water bodies, reducing the risk of environmental contamination.

Other core practices recommended in the proposed protocol also contributed to lowering chemical dependency. Fertilizer application based on soil test results ensured balanced nutrient supply, reducing the chance of pest outbreaks linked to over fertilizer application. Leaf color chart guided nitrogen management helped avoid excessive urea use and limited soft plant growth that attracts pests. Seed drum sowing improved crop geometry, promoting better air circulation and reducing humidity around plants, which helped suppress disease development. Conventional fields lacked these safeguards, often resulting in greater chemical use, lower RTI scores, and higher ecological and health risks.

III. District wise comparison of Reduced Toxicity Index

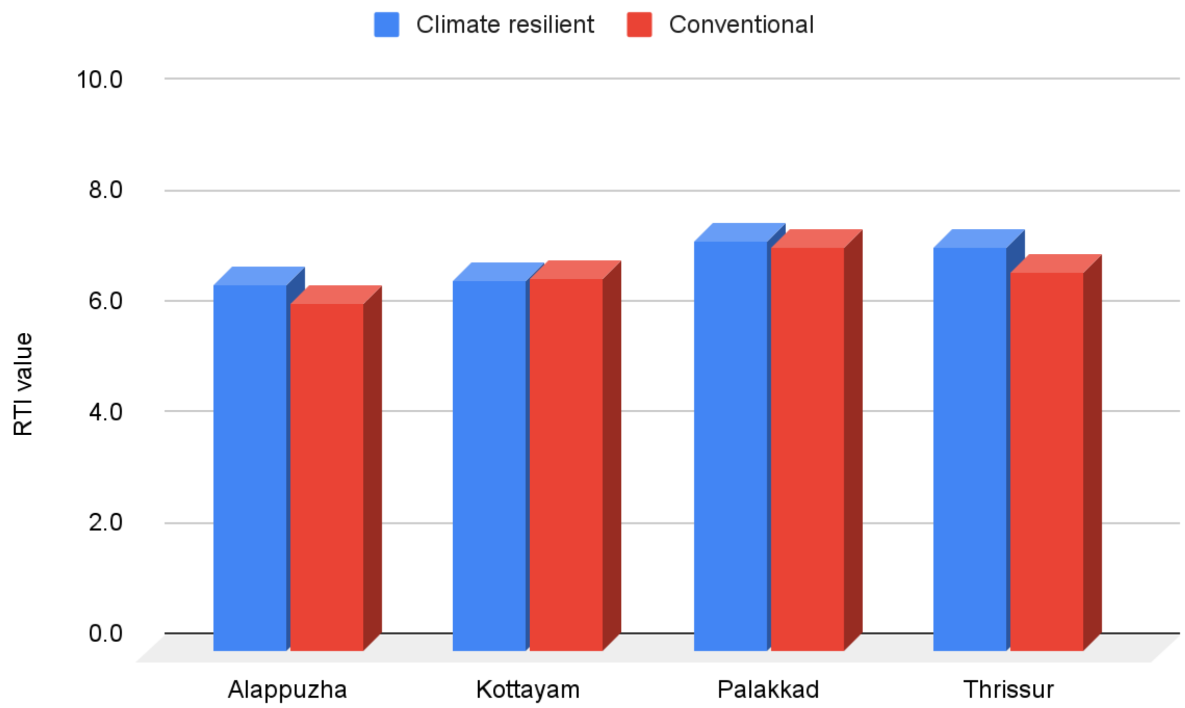


Fig.4.47. Reduced toxicity index among Climate-Resilient and Conventional paddy fields in key paddy growing districts of Kerala

The comparison of RTI across Palakkad, Thrissur, Kottayam, and Alappuzha shows varied effectiveness of climate-resilient farming in reducing environmental toxicity. Palakkad recorded the highest RTI values—7.4 in climate-resilient and 7.3 in conventional fields—reflecting widespread adoption of better farming practices even before intervention. Climate-resilient fields saw further improvement through biocontrol use, machine transplantation, and safe input management.

Thrissur showed the largest difference between systems (7.3 vs. 6.9), highlighting the strong impact of climate-resilient practices. Use of biocontrol agents, timely input application, and diverse agro-ecosystems supported significant toxicity reduction. Kottayam had identical RTI values (6.7) for both systems, suggesting limited impact of interventions. Cross-contamination from neighboring conventional farms, poor biocontrol quality, and weather conditions hindered outcomes despite climate-resilient efforts. Alappuzha reported the lowest RTI values (6.6 vs. 6.3), due to high pest pressure and frequent chemical use in its wetland ecosystem. Still, climate-resilient fields showed slight improvement through safer input use and seed drum sowing. Overall, the findings underscore the need to tailor climate-resilient interventions to local conditions for maximum effectiveness in reducing environmental toxicity.

IV. Findings

- The RTI assessment across four districts shows that region-specific factors strongly influence the environmental impact of paddy cultivation.
- Climate-resilient farming has generally led to lower toxicity levels, but the level of success varies based on local agronomic practices, ecological conditions, pest pressures, and institutional support.
- Palakkad and Thrissur demonstrate the benefits of sustainable practices when combined with farmer readiness and supportive infrastructure, resulting in significantly improved environmental outcomes.
- Kottayam and Alappuzha face challenges such as unfavorable weather, ecological constraints, and inter-field chemical interference, which reduce the potential benefits of climate-resilient interventions.
- The analysis emphasizes that reducing toxicity in paddy cultivation requires more than just adopting new methods; it also depends on supportive local environments that ensure consistent and effective practice.
- Achieving lasting environmental benefits will require local customization of interventions, improved input quality, and better coordination between conventional and climate-resilient plots across all regions.

4.3.6.2. Cost Effectiveness Index (CEI)

I. District wise analysis on Cost Effectiveness Index

a.Palakkad

Table 4.38. Cost effectiveness index of Palakkad (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Cost	1.36 ± 0.82	0.88 ± 0.31
Profit	4.32 ± 1.26	4.58 ± 1.02
Cost reduction	0.89 ± 0.58	0.50 ± 0.00
CEI score	6.57 ± 1.96	5.96 ± 1.12

In Palakkad, climate-resilient fields showed a higher CEI of 6.57 , compared to 5.96 in conventional fields (Table 4.38). This indicates that climate resilient fields offered better cost efficiency, driven by strategic input management and technological interventions that reduced overall cultivation expenses, thereby largely addressing climate change impacts.

The key factor enhancing cost effectiveness was the use of Trichocards in line with the climate resilient protocol. This biological pest control method significantly reduced pest infestations, lowering the dependency on chemical pesticides. Otherwise, changes in weather patterns directly contribute to increased pest infestations. As a result, farmers required fewer pesticide applications, which directly contributed to reduced input costs. Similar outcomes were observed in a study by Pavithra et al. (2021) conducted in Mandya district demonstrating that the integration of Trichocards in paddy fields effectively reduced stem borer incidence and enhanced yields. The study reported a mean yield of 57.46 q/ha and a benefit-cost ratio of 2.45 under IPM practices, highlighting the economic and ecological value of such biological interventions. Additionally, the cost reduction from the previous year was found to be higher in climate-resilient fields, further contributing to their higher CEI compared to conventional fields.

Another major factor contributing to the improved CEI was the substitution of the third dose of fertilizer with liquid fertilizers and micronutrients, which were applied using drones under the support of the Krishi Bhavan. This innovative approach not only enhanced nutrient delivery but also reduced costs significantly. A demonstration by Kerala Agricultural University (KAU) found that drone-assisted foliar application of micronutrients reduced operational time and costs to one-third compared to traditional methods, highlighting its cost-saving potential in paddy fields (The Hindu BusinessLine, 2022). Additionally, an integrated approach was followed wherein weedicides were applied along with the second dose of fertilizer. This practice helped avoid a separate round of application, thereby reducing labor and operational expenses further.

The improved CEI in Palakkad's climate-resilient fields highlights the impact of strategic interventions such as Trichocard use, drone-assisted nutrient delivery, and integrated input application. Despite the challenge of fragmented land holdings, paddy cultivation in Palakkad benefits from several favourable agro-ecological and institutional features. The region's fertile alluvial soils support robust crop growth, while naturally lower weed pressure reduces dependency on herbicides. Farmers also receive strong institutional backing through well-coordinated agricultural extension services. Although irrigation schedules can vary in tail-end areas of the Malampuzha canal system, access to canal irrigation—when available—supplements rainfall and enhances crop security.

b. Alappuzha

Table 4.39. Cost effectiveness index of Alappuzha (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Cost	1.00 ± 0.39	0.88 ± 0.31
Profit	5.00 ± 0	5.00 ± 0.00
Cost reduction	1.00 ± 0.77	0.83 ± 0.52
CEI score	7.00 ± 1.16	6.71 ± 0.75

In Alappuzha, the CEI for climate-resilient paddy cultivation was recorded at 7.00, slightly higher than the 6.71 observed for conventional methods (Table 4.39). This marginally higher CEI indicates that climate-resilient practices provided better overall economic efficiency during the cultivation period.

A key factor contributing to the improved cost efficiency in climate-resilient fields was the adoption of seed drums, as recommended in the climate-resilient protocol. These seed drums significantly reduced seed requirements to just 11–15 kg per acre, compared to the conventional method of manual broadcasting, which often required up to 50 kg per acre—including an additional purchase of around 10 kg. This reduction was not only cost-effective but was further supported by a government seed subsidy, which provided the seeds free of cost. Beyond cost savings, the use of seed drums improved agronomic outcomes. By enabling uniform seed placement and proper plant spacing, they encouraged better air and light penetration between plants, which in turn increased the number of productive tillers per plant. Proper spacing also reduced competition for nutrients and minimized lodging, leading to healthier crop stands and improved yields. A study by Ratnayake and Balasooriya (2013) demonstrated that the use of a manually operated drum seeder reduced seed usage by approximately 75% and increased yield by 37% compared to manual broadcasting, making it a practical and economically beneficial alternative in smallholder systems.

Trichocards were used for biological pest control, effectively reducing pest and disease infestations. This significantly lowered the number of chemical applications, further reducing input expenses. Moreover, climate-resilient fields followed recommended dosages of pesticides, weedicides, and fertilizers based on soil test results, avoiding overuse and promoting more efficient, cost-effective use of agrochemicals.

During the harvest period, untimely rainfall caused challenges in conventional fields where harvesting machines often became stuck, increasing rental costs. However, better crop spacing in climate-resilient fields enabled quicker and more efficient harvesting, helping to avoid these additional expenses.
Another important factor behind the higher CEI in climate-resilient fields was the notable reduction in overall costs compared to the previous season. Farmers reported improved cost management and resource efficiency under the new practices. While both climate-resilient and conventional fields recorded profits exceeding ₹10,000 per acre, the overall CEI remained higher for climate-resilient fields due to more efficient input use and better cost management practices. This reinforces the relative economic advantage of the climate-resilient approach throughout the cultivation period.

Alappuzha's below-sea-level paddy fields in Kuttanad present a cost-intensive cultivation environment due to the need for constant bund maintenance, controlled water levels, and precise scheduling to manage frequent flooding. Clay-rich soils require specialized field preparation, and labour shortages push reliance on costly mechanization. In this context, the adoption of a climate-resilient protocol emphasizing efficient water management, timely operations, and mechanized interventions—becomes essential to reduce risks and sustain economic viability.

c. Kottayam

Table 4.40. Cost effectiveness index of Kottayam (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Cost	2.00 ± 1.15	1.50 ± 0.75
Profit	1.25 ± 0.00	1.67 ± 0.72
Cost reduction	1.50 ± 0.87	1.50 ± 0.87
CEI score	4.75 ± 2.17	4.67 ± 0.88

In Kottayam, climate-resilient fields recorded a slightly higher average CEI of 4.75, compared to 4.67 in conventional fields (Table 4.40). The relatively low CEI values in both systems reflect generally low cost effectiveness in the district.

Farmers in Kottayam did not receive seed subsidies and had to purchase seeds themselves, increasing input costs. The region's low-lying topography makes fields especially vulnerable to pest, disease, weed infestations and salt water intrusion. In climate-resilient fields, the use of biocontrol agents was ineffective due to unfavorable weather conditions, forcing farmers to rely more on chemical pesticides, which further raised production costs.

In the Kumarakom region, saltwater intrusion has emerged as a significant challenge, severely affecting crop quality and quantity. Despite the presence of the Thanneermukkam bund—a regulatory structure built to prevent tidal saltwater from entering the low-lying paddy fields of Kuttanad—saline seepage has been reported across several areas, including Kumarakom. This intrusion has led to soil acidification, with pH levels dropping to as low as 3–4, causing plant damage and drastically reducing yields. The compromised grain quality resulted in Supplyco rejecting the produce, forcing farmers to sell their harvest to duck farmers at nearly half the government-set procurement price. While this allowed them to avoid costs related to bagging, transportation, and loading, their overall income was significantly reduced. In conventional fields, where yields were especially poor, some farmers opted not to harvest at all, as the cost of harvesting would have exceeded any returns. These outcomes contributed to a lower CEI in conventional systems. Though the Thanneermukkam bund was originally intended to support freshwater agriculture by blocking saltwater during the dry season, political issues and limited saline flushing have led to ecological imbalances, increased weed growth, and declining fish populations—further complicating the region's agricultural sustainability.

Kottayam's geography plays a significant role in shaping the cost dynamics of paddy cultivation. Much of the district falls within the Kuttanad region, known for its below-sea-level farming system. This unique agro-ecological zone is heavily influenced by tidal flows, backwaters, and seasonal flooding, which complicate timely agricultural operations. The need for water management infrastructure, such as bunds and pumps, adds to operational costs. Furthermore, salinity intrusion—especially during dry spells or when water regulation is delayed—can stress crops and reduce input efficiency. The low-lying nature of the terrain also limits field accessibility during certain periods, often delaying sowing, transplanting, and harvesting activities. These geographical and hydrological constraints contribute to higher variability in cost effectiveness and yield outcomes across the district.

d. Thrissur

Table 4.41. Cost effectiveness index of Thrissur (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Cost	0.75 ± 0.00	0.75 ± 0.00
Profit	0.88 ± 0.66	1.42 ± 0.75
Cost reduction	1.39 ± 0.42	1.25 ± 0.00
CEI score	2.97 ± 0.99	3.52 ± 0.75

Thrissur presents a distinct case in the CEI analysis, where conventional fields recorded a slightly higher CEI 3.52 compared to climate-resilient fields 2.97 (Table 4.41) – a reversal of the trend seen in other districts. The CEI values in both systems are relatively low, reflecting generally poor cost effectiveness during the cultivation period in this district. This outcome can be attributed to several key factors.

In Thrissur, fields under the climate-resilient paddy farming protocol were sown earlier than usual in an effort to avoid rainfall during the harvest period. However, an unexpected spell of heavy rain shortly after sowing led to severe flooding and widespread crop damage, forcing many farmers to resow their fields and significantly increasing production costs. Compounding this, only a portion of the farmers adopted biological pest control measures such as Trichocards. This partial and inconsistent adoption failed to suppress pest populations effectively, leading to widespread infestations. As a result, farmers had to rely on chemical pesticides, which further increased input costs. Rainfall during the harvest period also caused delays, yield losses, and elevated harvester rental charges due to waterlogged fields. In contrast, many conventional fields had not yet been sown when the flooding occurred and thus escaped early-stage damage. Consequently, profit levels were higher in conventional fields during this season, reflected in their marginally better CEI values. Overall, the increased costs and lower returns in climate-resilient fields were largely the result of partial and inconsistent implementation of the prescribed protocol, underscoring the importance of full adoption for realizing its intended benefits.

Thrissur's paddy farming, particularly in the Kole lands, is shaped by its low-lying terrain and high water table, making it prone to seasonal flooding and poor drainage. These conditions often delay field operations and raise input costs due to crop losses and replanting needs. The resulting cost inefficiency highlights the relevance of climate-resilient protocols tailored to manage water-logged and flood-prone ecosystems effectively.

II. Comparative Analysis of CEI of Climate-Resilient and Conventional Paddy Cultivation in Kerala

Table 4.42. Cost effectiveness index values of Climate- Resilient and Conventional paddy cultivation (Values are Mean ± SD)

District	Climate resilient	Conventional
Alappuzha	7.00 ± 1.16	6.71 ± 0.75
Kottayam	4.75 ± 2.17	4.67 ± 0.88
Palakkad	6.42 ± 1.97	5.96 ± 1.12
Thrissur	3.11 ± 1.36	3.52 ± 0.75

The comparative analysis between climate-resilient and conventional paddy fields showed that structured adoption of climate-resilient protocols led to significantly higher cost effectiveness. This improvement stemmed from scientifically informed practices such as soil test-based fertilizer and lime application, use of seed drums for optimal seed rate and spacing, biological seed treatment with Pseudomonas, and pest control through biocontrol agents like Trichocards. These interventions ensured precise input use, better plant health, and improved operational efficiency. Foliar application of micronutrients, including drone-based spraying in some areas, further boosted yields while reducing labour and input costs.

In contrast, conventional fields relied on arbitrary input use without diagnostic planning, leading to nutrient imbalances and higher pest susceptibility. Manual broadcasting caused uneven plant stands, making crops more prone to pest attacks and disease. Overdependence on chemical pesticides and fertilizers often failed to improve yields, resulting in poor cost efficiency. Without integrated planning, these systems were also more vulnerable to climatic disruptions and harvest delays. Overall, the climate-resilient protocol's integrated approach improved both productivity and adaptability, offering a more economically viable model for paddy cultivation in Kerala.

III. District wise comparison of Cost Effectiveness Index

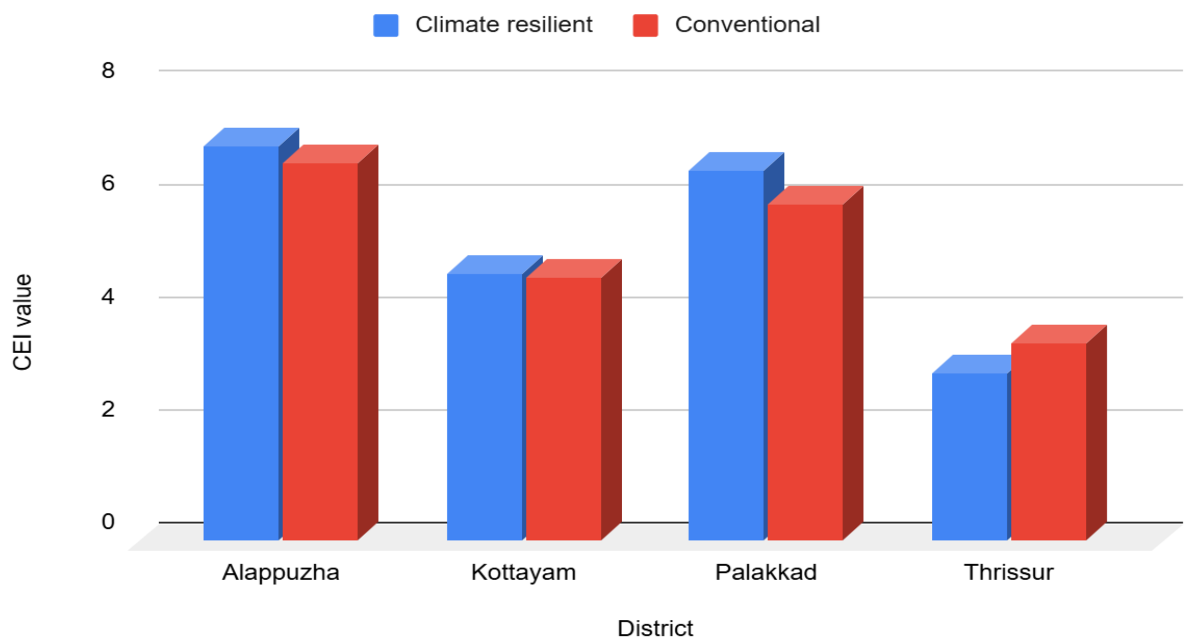


Fig 4.48. Cost effectiveness index among Climate-Resilient and Conventional paddy fields in key paddy growing districts of Kerala

The comparative CEI analysis across districts highlights that full adoption of the climate-resilient farming protocol consistently led to better cost effectiveness. In Alappuzha, where farmers widely implemented the protocol alongside efficient water management and mechanization, the highest CEI was recorded—demonstrating the added value of refined input use even in a well-optimized system. Palakkad also showed strong results, with climate-resilient fields outperforming conventional ones due to improved input efficiency and growing mechanization. In contrast, Kottayam's marginal CEI difference reflects challenges like fragmented holdings and saltwater intrusion in areas like Kumarakom, which affected both yield and grain quality—limiting the full benefits of the protocol.

Thrissur was the only district where conventional fields outperformed climate-resilient ones. Here, partial and inconsistent adoption—such as limited use of Trichocards—led to pest outbreaks, increased pesticide reliance, and higher costs. The ecological consequences of heavy chemical use further worsened outcomes. Overall, the results affirm that the success of climate-resilient farming depends not just on the protocol itself, but on its complete and consistent adoption, supported by location-specific strategies and ecological awareness.

IV. Findings

- The comparative analysis across four districts in Kerala shows that climate-resilient paddy cultivation improves cost effectiveness, especially when fully implemented with strong farmer cooperation.
- Districts with full adoption of recommended practices—including seed drum sowing, soil test-based fertilizer and lime application, biocontrol methods like Trichocards, and micronutrient use—achieved greater input efficiency and lower cultivation costs.
- In Alappuzha, strong farmer cooperation and high protocol adherence enabled widespread mechanization and precise input management, resulting in efficient cultivation despite the challenges of below-sea-level farming.
- In Palakkad, coordinated farmer efforts, soil test-based fertilizer and micronutrient use, and integrated pest and weed management contributed to improved cost effectiveness, supported by strong extension services.
- In Kottayam, despite high farmer cooperation and protocol adherence, cost effectiveness remained low in areas like Kumarakom due to environmental stress from saltwater intrusion, which affected crop quality and yield.
- In Thrissur, poor outcomes were recorded due to low farmer cooperation and incomplete adoption of the protocol, including limited Trichocard application. This led to pest outbreaks, increased pesticide use, and higher cultivation costs.
- The findings highlight that both full adoption of the protocol and collective farmer action are critical for realizing the benefits of climate-resilient agriculture.
- Local environmental factors must also be addressed through site-specific strategies and targeted institutional support to achieve sustainable improvements.
- Overall, the climate-resilient protocol provides a clear pathway to higher cost effectiveness and more sustainable paddy cultivation.

4.3.6.3. Yield Potential Index (YPI)
I. District wise analysis on Yield Potential Index
a. Palakkad

Table 4.43. Yield potential index of Palakkad (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Yield (Q)/acre (24-25)	2.27 ± 0.49	2.29 ± 0.51
Yield improvement (%)	2.78 ± 1.49	1.88 ± 1.05
YPI score	5.06 ± 1.61	4.17 ± 1.29

In Palakkad, climate-resilient paddy fields demonstrated a YPI, scoring 5.06 compared to 4.17 in conventional fields (Table 4.43). This elevated YPI indicates not only greater yield levels but also more consistent yield improvements over the previous season. Notably, the yield improvement from the preceding crop cycle was significantly higher in the climate-resilient fields than in the conventional ones.

Several improved agronomic practices contributed to this enhanced performance. The application of Trichocard effectively reduced pest infestations, supporting healthier crop development. Studies in Kerala have shown that releases at approximately 100,000–150,000 wasps/ha decreased incidences of dead heart and white ear by over 70%, and resulted in an increase in yield between 26–45% compared to pesticide-treated controls (Karthikeyan et al. 2007). Machine transplantation facilitated uniform crop establishment and stronger plant stands, while the targeted application of micronutrients promoted robust plant growth and improved resilience to environmental stresses. These integrated interventions collectively contributed to increased and more reliable yields in the climate-resilient plots.

In contrast, conventional fields exhibited lower and more variable yield outcomes. The lack of uniformity in adopting pest and nutrient management strategies, coupled with reliance on traditional practices, likely limited their yield gains and contributed to inconsistent performance across plots.

Palakkad consistently records high agricultural yields due to its unique blend of geographic and institutional strengths. The presence of the Palakkad Gap in the Western Ghats creates a favorable agro-climatic zone, while fertile plains and reliable water sources from rivers like Bharathapuzha, supported by major irrigation projects such as Malampuzha and Pothundi, ensure optimal growing conditions. Combined with strong agricultural infrastructure, including the Regional Agricultural Research Station and active extension services, these factors enable Palakkad to achieve high productivity, particularly in paddy cultivation, under both conventional and climate-resilient farming systems.

b. Alappuzha

Table 4.44.Yield potential index of Alappuzha (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Yield (Q)/acre (24-25)	3.75 ± 0.00	2.92 ± 0.65
Yield improvement (%)	2.08 ± 0.65	1.88 ± 1.05
YPI score	5.83 ± 0.65	4.79 ± 1.46

In Alappuzha, climate resilient paddy cultivation achieved a higher YPI of 5.83, compared to a YPI of 4.7 for conventional methods (Table 4.44). This improvement was driven by better agronomic practices that enhanced yield stability and efficiency.

Key among these was the use of seed drums, ensuring proper spacing and lower seed rates, which enhanced nutrient and sunlight use, reduced pest susceptibility, and minimized the need for chemical inputs. On-Farm Demonstration in Andhra Pradesh conducted during 2010–2012 showed that drum seeding increased grain yield by approximately 12.7% (from 5,041 to 5,684 kg ha^{-1}), while reducing cultivation costs by 19.5% and enhancing net returns by 34.3%. Agronomic attributes such as tiller number, panicle length, and grain count per panicle also saw significant gains (Kumari et al. 2016). Biological controls like trichocards further limited pesticide use, applied only early and in recommended doses. Proper spacing also enabled efficient harvesting, reducing grain loss. In contrast, conventional broadcasting led to overcrowding, poor plant health, and excessive pesticide use, lowering yield potential. The average yield increased modestly from 27 quintals per acre in 2023–24 to 28 quintals per acre in 2024–25. While this year-on-year gain appears minimal, it still reflects higher-than-typical yields for most farmers, suggesting that climate-resilient practices are sustaining strong productivity. However, the overall yield potential index remains low, primarily due to the limited improvement in yield over the previous season, which affects the sub-index for yield improvement.

Alappuzha's distinct below sea-level terrain, particularly in the Kuttanad region, plays a significant role in influencing paddy yield. The flat, low-lying landscape, coupled with a high groundwater table and controlled water inflow from rivers, ensures consistent soil moisture levels conducive to rice growth. Additionally, the integrated canal network facilitates efficient irrigation and drainage, enabling timely agricultural operations. These agro-ecological features, along with coordinated field management, contribute to the district's characteristic yield performance.

c. Kottayam

Table 4.45. Yield potential index of Kottayam (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Yield (Q)/acre (24-25)	1.25 ± 0.00	1.67 ± 0.72
Yield improvement (%)	3.75 ± 2.17	2.50 ± 2.17
YPI score	5.00 ± 2.17	4.17 ± 2.89

In Kottayam, climate-resilient fields recorded a higher YPI, scoring 5.00 compared to 4.17 in conventional fields (Table 4.45). Though average yields in climate resilient fields were lower than typical expectations, their strong year-on-year improvement led to higher index scores. These gains stemmed from improved practices, even if absolute yields remained modest.

The yield was affected by saltwater intrusion in two fields and delayed sowing in another, reducing output despite better input management. In contrast, conventional fields showed higher yields in some areas, but greater variability and negative yield trends overall—exacerbated by heavy rainfall, non-harvest in one field, and widespread broadcast sowing, which increased plant competition and pest issues.

Only 46% of the climate resilient fields were sown using seed drum, but correct spacing and structured management practices like timely pesticide application and trichocard use helped stabilize performance. Despite environmental stressors, climate resilient fields demonstrated better adaptability and more reliable yield trends than conventional methods.

Kottayam district, with its extensive low-lying paddy fields in regions like Kuttanad, is highly susceptible to monsoon flooding and saltwater intrusion due to its below-sea-level topography and proximity to backwaters. These geographical challenges frequently lead to waterlogging and soil salinity, adversely affecting paddy yields. Sustaining productivity in such conditions requires climate-resilient practices, improved drainage, and protective bunds tailored to this vulnerable agro-ecological zone

d. Thrissur

Table 4.46. Yield potential index of Thrissur (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Yield (Q)/acre (24-25)	1.53 ± 0.55	1.88 ± 0.68
Yield improvement (%)	2.92 ± 1.98	2.71 ± 1.66
YPI score	4.44 ± 2.35	4.58 ± 2.33

In Thrissur, yield performance reflected both management practices and external conditions. The YPI was slightly higher in conventional fields at 4.58, compared to 4.44 in climate-resilient fields (Table 4.46). This outcome was largely influenced by better farmer cooperation and more consistent implementation of conventional practices, whereas the climate-resilient protocol saw uneven adoption across fields and absence of mechanization limiting its impact on yield.

Unseasonal rainfall at the time of harvest further affected yield in several climate-resilient plots, causing delays and losses. However, when compared to the previous season, climate-resilient fields showed a modest improvement in yield, outperforming conventional plots in relative terms. This suggests that, despite challenges, the climate-resilient approach holds potential for enhancing yield outcomes when implemented comprehensively.

II. Comparative Analysis of YPI of Climate-Resilient and Conventional Paddy Cultivation in Kerala

Table 4.47. Yield potential index values of Climate- resilient and Conventional paddy cultivation (Values are Mean ± SD)

District	Climate resilient	Conventional
Alappuzha	5.83 ± 0.65	4.79 ± 1.46
Kottayam	5.00 ± 2.17	4.17 ± 2.89
Palakkad	5.06 ± 1.61	4.17 ± 1.29
Thrissur	4.44 ± 2.35	4.58 ± 2.33

Yield performance, measured through both absolute yield and percentage improvement over previous crops, was consistently higher in climate resilient fields. Climate-resilient practices, including soil test-based fertilizer application, optimized plant spacing, reduced biotic stress, and timely operations, ensured vigorous crop growth and higher tillering. Improved crop stand quality facilitated by uniform sowing also contributed to increased photosynthetic efficiency and better grain filling. In many districts, climate-resilient fields crossed the 3,500 kg/acre threshold, qualifying for the highest YPI score range. In contrast, conventional fields struggled with nutrient imbalances, dense and uneven stands, and greater pest damage, resulting in lower yields and minimal improvement over previous performance.

III. District wise comparison of Yield Potential Index

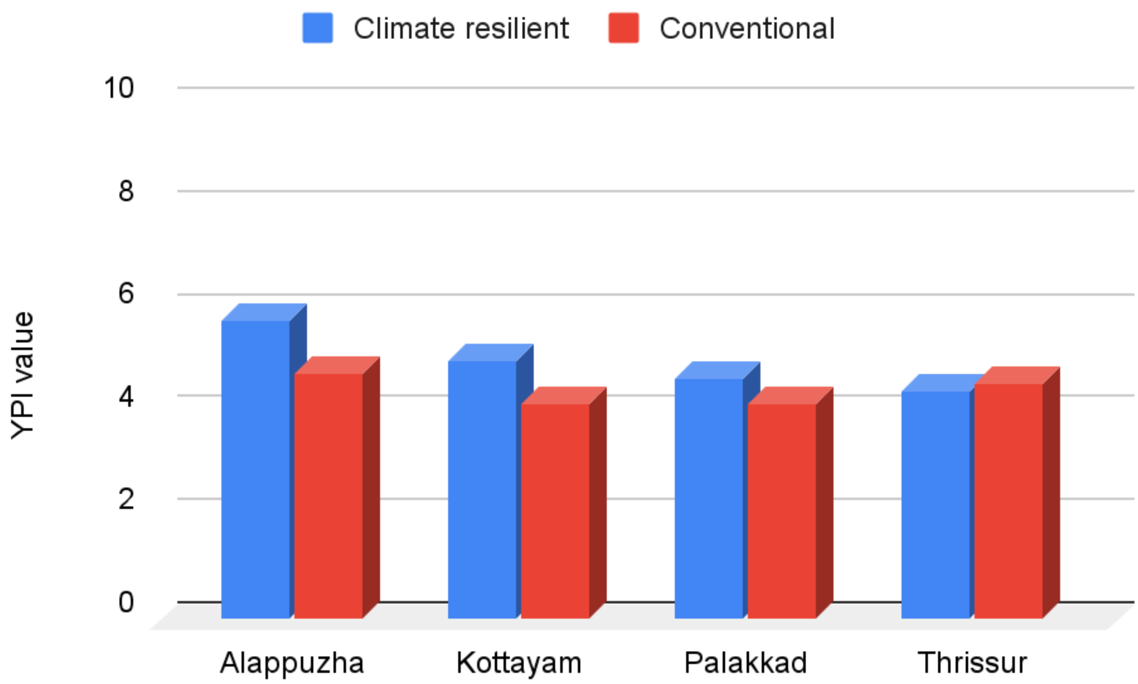


Fig 4.49. Yield potential index among Climate-Resilient and Conventional paddy fields in key paddy growing districts of Kerala

The district-wise analysis of the YPI demonstrates that climate-resilient paddy cultivation practices generally outperform conventional methods across Kerala. In Alappuzha, climate-resilient fields achieved the highest YPI, driven by the adoption of improved practices such as seed drum sowing, mechanization, and biological pest control. Kottayam also showed better performance under the climate-resilient approach, with higher YPI scores reflecting yield gains despite challenges like flooding and saltwater intrusion.

In Palakkad, where natural growing conditions are favorable, the use of machine transplanting and targeted nutrient management under climate-resilient practices led to noticeable yield improvements over conventional methods. Thrissur was the only district where conventional fields recorded a slightly higher YPI, largely due to the rainfall at the time of harvest. Overall, the results indicate that climate-resilient practices contribute to improved yield potential across diverse agro-ecological settings, particularly when interventions are fully and appropriately implemented.

IV. Findings

- The YPI analysis across Alappuzha, Kottayam, Palakkad, and Thrissur shows that climate-resilient paddy cultivation generally outperforms conventional methods in enhancing yield potential.
- Climate-resilient fields recorded higher YPI scores in three out of four districts, demonstrating the effectiveness of practices such as seed drum sowing, machine transplanting, biological pest control, and targeted nutrient management.

- These interventions were particularly valuable in environmentally stressed regions facing challenges like flooding and saltwater intrusion.
- Thrissur was the exception, where conventional fields marginally outperformed climate-resilient ones due to unexpected rainfall at harvest, absence of mechanization, and only partial protocol adoption.
- In Alappuzha, climate-resilient fields achieved the highest YPI score, supported by mechanization, seed drum sowing, and biological pest control, which maintained high yields in the below-sea-level farming areas of Kuttanad.
- In Kottayam, climate-resilient fields outperformed conventional fields despite environmental challenges like flooding and saltwater intrusion. Improved spacing, timely pest control, and adaptive management led to yield improvements over the previous season, although absolute yields were modest in some areas.
- Palakkad showed a moderate advantage for climate-resilient fields, aided by naturally favorable conditions and strong agricultural infrastructure. Practices like machine transplanting, biological pest control, and balanced nutrient management led to consistent yield improvements.
- The findings emphasize the need for consistent adoption of climate-resilient practices to enhance productivity and improve yield stability across Kerala's diverse agro-ecological zones.

4.3.6.4. Adoption Of Improved Technology Index (AITI)

I. District wise analysis on Adoption of Improved Technology Index

a. Palakkad

Table 4.48. Adoption of improved technology index of Palakkad (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Adoption level	3.00 ± 3.06	2.00 ± 3.10
Sowing uniformity	4.00 ± 0.00	3.00 ± 0.52
AIT score	7.27 ± 3.06	5.33 ± 3.61

Palakkad's climate resilient fields recorded a strong adoption score of 7.27, higher than 5.33 in conventional fields (Table 4.48). This reflects better awareness and practice of improved methods among the climate resilient group.

The elevated score in climate resilient fields is primarily driven by the widespread use of machine transplantation. Notably, 54% of farmers in climate resilient fields practiced machine transplantation, compared to only 33% in conventional fields. Machine transplantation offers uniform plant spacing and consistent crop stands, which significantly reduce weed, pest, and disease pressures. These advantages translate into lower input costs and enhanced crop performance. Additionally, machine transplantation is less labor-intensive, faster, and more precise than manual methods, making it a more efficient and cost-effective option. While conventional fields in Palakkad demonstrated relatively high technology adoption, the lower index reflects continued reliance on traditional practices such as manual transplantation and broadcasting, which often result in uneven crop establishment and higher labor requirements.

b. Alappuzha

Table 4.49. Adoption of improved technology index of Alappuzha (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Adoption level	4.00 ± 3.10	1.00 ± 2.45
Sowing uniformity	3.17 ± 0.98	2.33 ± 0.82
AIT score	7.17 ± 4.02	3.33 ± 3.27

Alappuzha showed a clear disparity in technology adoption, with climate resilient fields scoring significantly higher (7.17) compared to conventional fields (3.33) (Table 4.49). This improvement is mainly due to the use of seed drums for sowing, adopted by 67% of farmers in climate resilient fields, compared to only 17% in conventional fields. Seed drum sowing ensures uniform plant spacing, which helps achieve a good crop stand while reducing seed rates. It also lowers weed pressure, pest and disease incidence, improves aeration, and makes intercultural operations like weeding and fertilization easier. Furthermore, it promotes active tillering and simplifies harvesting, reducing both time and operational costs. In contrast, conventional fields largely depend on manual broadcasting, leading to uneven crop stands and increased input usage, which limits efficiency and technological advancement.

c. Kottayam

Table 4.50. Adoption of improved technology index of Kottayam (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Adoption level	2.00 ± 3.46	0.00 ± 0.00
Sowing uniformity	1.33 ± 0.58	1.33 ± 0.58
AIT score	3.33 ± 4.04	1.33 ± 0.58

In Kottayam, climate resilient fields had a moderate average score of 3.33, compared to 1.33 for conventional fields (Table 4.50). In climate resilient fields, only 24% of the area was sown using seed drums, while the rest was sown through manual broadcasting, leading to uneven crop stands and reduced efficiency. In conventional fields, the entire area was sown by manual broadcasting, resulting in comparatively lower crop uniformity. This lack of technological intervention contributed to the significantly lower index value observed in conventional farming systems.

d. Thrissur

Table 4.51. Adoption of improved technology index of Thrissur (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Adoption level	0.00 ± 0.00	0.00 ± 0.00
Sowing uniformity	2.00 ± 0.00	2.00 ± 0.00
AIT score	2.00 ± 0.00	2.00 ± 0.00

In Thrissur, both climate resilient and conventional fields scored 2.00 (Table 4.51), indicating no observed difference in technology adoption between the groups. This reflects minimal adoption of improved agricultural technologies across the district. In both farming systems, sowing was carried out through manual transplantation, which contributed to less uniform crop stands and limited efficiency. The lack of advanced mechanization and uniform planting techniques has resulted in reduced technology adoption and lower productivity.

II. Comparative Analysis of AITI of Climate-Resilient and Conventional Paddy Cultivation in Kerala

Table 4.52. Adoption of improved technology index values of Climate-Resilient and Conventional paddy cultivation (Values are Mean ± SD)

District	Climate resilient	Conventional
Alappuzha	7.17 ± 4.02	3.33 ± 3.27
Kottayam	3.33 ± 4.04	1.33 ± 0.58
Palakkad	7.27 ± 3.06	5.33 ± 3.61
Thrissur	2.00 ± 0.00	2.00 ± 0.00

The climate-resilient protocol promoted widespread adoption of seed drums and mechanical transplanters, leading to a high rate of mechanized sowing across multiple sites. The use of seed drums ensured uniform seed spacing and optimal plant population, which not only improved tillering but also supported efficient weeding and harvesting. Uniform crop stands with proper spacing contributed to lower pest and disease incidence and achieved maximum scores on the crop stand sub-index, reflecting better early crop performance.

In contrast, conventional fields largely depended on manual broadcasting, resulting in uneven seed distribution, inconsistent sowing depth, and irregular spacing. This led to poor stand establishment, reduced tillering, and increased intra-crop competition. These factors negatively impacted weed control and pest management, contributing to lower scores on the Adoption of Improved Techniques Index (AITI). The absence of mechanized sowing also limited labor efficiency and standardization of field operations.

III. District wise comparison of Adoption of Improved Technology

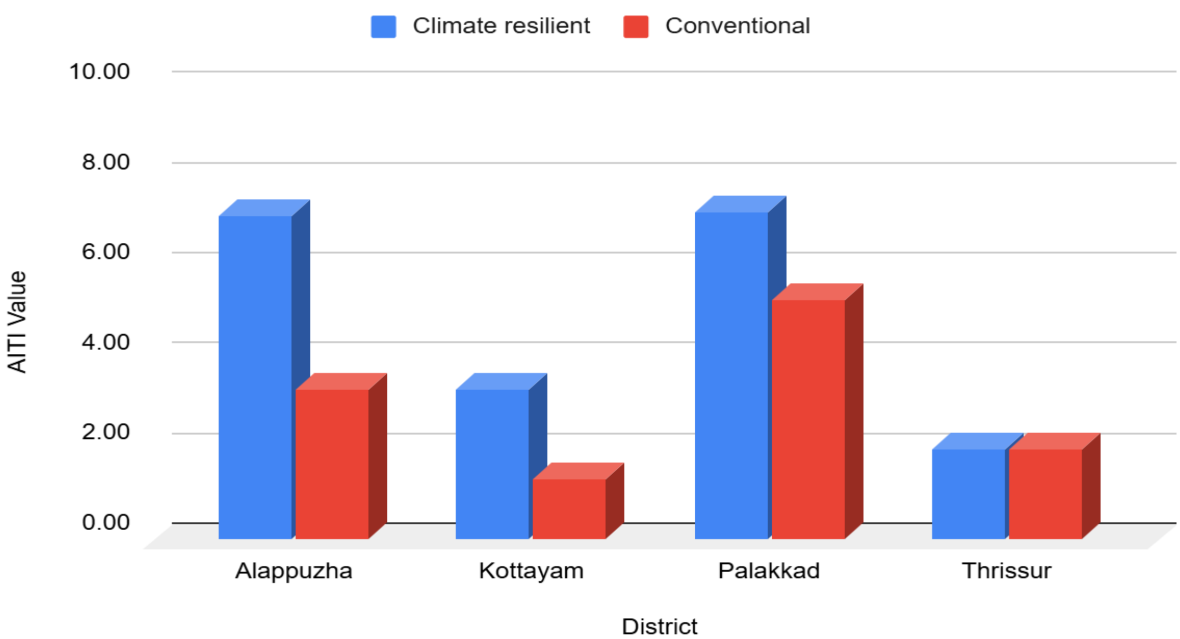


Fig 4.50. Adoption of improved technology index among Climate-Resilient an Conventional paddy fields in key paddy growing districts of Kerala

The AITI analysis across Palakkad, Alappuzha, Kottayam, and Thrissur reveals clear differences in the uptake of modern agricultural practices between climate-resilient and conventional farming systems. Overall, climate-resilient fields showed higher AITI scores in three out of the four districts, indicating better integration of improved sowing techniques and mechanization. Practices such as machine transplantation and seed drum sowing played a key role in enhancing crop stand uniformity, reducing input costs, and improving operational efficiency. However, the degree of adoption varied significantly, with districts like Palakkad and Alappuzha demonstrating stronger technology adoption, while Kottayam and Thrissur lagged behind.

In Palakkad, climate-resilient fields recorded a notably higher AITI score (7.27) compared to conventional fields (5.33), largely driven by the widespread use of machine transplantation. This technique improved planting uniformity and crop health while reducing labor costs and input usage. Despite some adoption in conventional fields, reliance on manual methods remained more prevalent.

Alappuzha also showed a significant difference, with climate-resilient fields scoring 7.17 on the AITI score, more than double the score of conventional fields (3.33). The widespread use of seed drums in climate-resilient plots improved sowing uniformity and agronomic efficiency, while conventional fields continued to rely heavily on broadcasting, resulting in uneven crop stands and higher production costs.

In Kottayam, adoption levels were generally low in both systems, but climate-resilient fields performed marginally better with an AITI score of 3.33 compared to 1.33 in conventional fields. Limited use of seed drums and the predominance of manual broadcasting in both systems contributed to the lower scores and less efficient crop establishment.

Thrissur reported the lowest and equal AITI score (2.00) for both climate-resilient and conventional fields. There was no evidence of improved technology adoption, as all sowing was done manually. The complete absence of mechanization and uniform planting practices points to a need for stronger awareness and access to agricultural innovations in the district.

IV. Findings

- The AITI varied notably across Palakkad, Alappuzha, Kottayam, and Thrissur, with climate-resilient farming systems showing higher technology uptake than conventional systems.
- Climate-resilient fields exhibited consistently higher levels of technology adoption in Palakkad, Alappuzha, and Kottayam, driven by the use of mechanized methods like machine transplanting and seed drum sowing.
- These technologies contributed to better crop establishment, improved planting uniformity, and reductions in labor and input costs.
- In Palakkad, the widespread use of mechanization under climate-resilient farming enhanced planting efficiency and operational precision.
- In Alappuzha, strong adoption of seed drum sowing techniques optimized plant spacing and minimized resource wastage.

- In Kottayam, adoption of improved techniques was limited, as traditional methods like broadcasting continued to dominate despite some progress.
- In Thrissur, both climate-resilient and conventional fields showed minimal uptake of improved technologies, indicating a lack of differentiation and stagnation in technological advancement.
- The findings highlight the positive role of climate-resilient approaches in accelerating technology adoption, especially in districts with structured support and targeted interventions.
- However, uneven progress across districts calls for strengthened extension services, better access to machinery, and context-specific training programs to encourage wider adoption—particularly in areas where traditional practices remain prevalent.

4.3.6.5. WEATHER PATTERN IMPACT INDEX (WPII)

I. District wise analysis on Weather Pattern Impact Index

a. Palakkad

Table 4.53. Weather pattern impact index of Palakkad (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Delay in operation	3.95 ± 0.21	4.00 ± 0
Additional cost incurred	5.19 ± 1	5.00 ± 0.77
WPII score	9.14 ± 0.95	9.00 ± 0.77

In Palakkad, the WPII is notably high for both climate-resilient (9.14) and conventional samithi fields (9.00) (Table 4.53), indicating strong resistance to weather fluctuations in both systems. Cultivation in this region began in mid-November, allowing farmers to complete harvesting by mid-March—well before the onset of summer showers. As a result, the occurrence of these showers had no significant impact on crop productivity, and no major operational delays were observed in either the climate-resilient or conventional fields due to altered weather patterns.

However, some farmers in conventional fields reported increased incidences of pest and disease attacks attributed to abnormal weather conditions. This led to a higher expenditure on plant protection measures, thereby raising the overall cost of cultivation in those fields. Additionally, post-sowing flooding in conventional fields caused the bunds to break, resulting in further repair costs. Consequently, the WPII value for conventional fields is slightly lower, suggesting a higher vulnerability to climatic stress when compared to climate-resilient fields.

In contrast, cultivation in climate-resilient fields was carried out following the proposed protocol, which included fertilizer application based on soil test recommendations, the use of biocontrol agents for managing pests, and the application of micronutrient mixes. These improved agronomic practices enhanced plant health and uniform crop stand, enabling the fields to better withstand abnormal weather conditions. Furthermore, pest, disease, and weed infestations related to climatic variability were found to be minimal in these fields, further supporting their superior adaptability and resilience under changing climate conditions.

b. Alappuzha

Table 4.54. Weather pattern impact index of Alappuzha (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Delay in operation	2.50 ± 0.84	2.67 ± 0.82
Additional cost incurred	4.50 ± 1.34	3.75 ± 0.82
WPII score	7.00 ± 1.76	6.42 ± 0.86

In Alappuzha, the WPII indicates that climate-resilient fields (7.00) performed better under climatic stress compared to conventional fields (6.42) (Table 4.54), suggesting greater resilience in the former. The fields were located in the Kuttanad region of Alappuzha, a low-lying area situated below mean sea level and highly susceptible to flooding during heavy rainfall. Shortly after sowing, untimely rains occurred, posing challenges to crop establishment. The adverse effects of this abnormal weather were more severe in conventional fields. This was largely due to the manual broadcasting method of sowing, which resulted in uneven crop stands and higher incidences of pest and disease outbreaks. Additionally, the irregular spacing made harvesting labor-intensive and time-consuming. As a result, the additional cost incurred in conventional fields due to climate-related stresses—such as pest and disease control, and harvesting—was significantly higher compared to climate-resilient fields.

In contrast, climate-resilient fields employed seed drum sowing, which promoted uniform crop establishment with proper plant spacing. This not only reduced pest, disease, and weed infestations but also made harvesting more efficient and less costly. Additionally, the components of the proposed protocol were strictly followed in these fields—such as fertilizer application based on soil test results, use of biocontrol agents for plant protection, and application of a balanced micronutrient mix. Together, these practices improved overall crop health, strengthened plant vigor, and enabled the crop to better withstand weather abnormalities compared to conventional fields. These improved agronomic practices helped buffer the crop against the negative impacts of erratic weather while significantly reducing labor, input expenses, and yield losses.

Both farming systems experienced harvest delays due to unseasonal rainfall, which increased harvesting costs and caused some yield losses. These challenges were largely a result of delayed sowing, which shifted harvesting into the summer shower period. Despite these setbacks, climate-resilient fields performed better, showing lower levels of damage and more stable yields. Although deductions were made by procurement agents for high moisture content in grains across both systems, the climate-resilient fields demonstrated greater resilience and helped reduce the overall economic impact on farmers.

c. Kottayam

Table 4.55.Weather pattern impact index of Kottayam (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Delay in operation	2.00 ± 1.73	2.67 ± 1.15
Additional cost incurred	4.50 ± 2.60	1.50 ± 0.00
WPII score	6.50 ± 0.87	4.50 ± 1.41

The analysis of the WPII in Kottayam reveals a notable difference in resilience between climate resilient and conventional paddy fields. Climate resilient plots recorded an average index score of 6.5, while conventional fields lagged behind with a significantly lower average score of 4.17 (Table 4.55). This indicates that fields under the climate resilient protocol were better equipped to manage and recover from weather change events.

In Kottayam, among the climate-resilient fields, two demonstrated high resilience by ensuring timely operations and effectively managing additional costs arising from weather-related disruptions. Their proactive approach helped minimize yield loss and maintain overall productivity. In contrast, one field experienced significant delays due to late sowing, which lowered its index score despite incurring fewer additional costs, thus reducing the overall average.

Additionally, saltwater intrusion affected both climate-resilient and conventional fields, particularly in areas like Kumarakom, leading to pest and disease outbreaks and increasing input costs across both systems.

Conventional fields, overall, showed limited adaptability to changing weather conditions. Substantial expenses were incurred for managing pest and disease outbreaks triggered by weather-related stress. Erratic rainfall caused delays in field operations, and while one field showed relatively less delay, the lack of timely follow-up actions and poor implementation of corrective measures contributed to the low performance of conventional plots.

d. Thrissur

Table 4.56. Weather pattern impact index of Thrissur (Values are Mean ± SD)

Sub indices	Climate resilient field	Conventional field
Delay in operation	2.78 ± 0.67	4.00 ± 0.00
Additional cost incurred	4.33 ± 1.58	4.75 ± 0.61
WPII score	7.11 ± 1.69	8.75 ± 0.61

In Thrissur, the WPII presents an unusual case where conventional fields (8.75) scored higher than the climate resilient fields (7.11) (Table 4.56). This deviation from the general trend observed in other districts is primarily attributed to unexpected and severe flooding that disproportionately affected the climate resilient plots.

The flooding occurred during critical stages of crop establishment in the climate resilient fields, which had already been sown following the recommended calendar. As a result, these fields faced complete crop loss in many areas, forcing farmers to transplant again, often sourcing seedlings from external nurseries or other farmers. This led to significant unplanned expenses, including purchasing new seedlings, additional labour for re-transplanting, and extra fertilizer and input costs to support the delayed crop. Rainfall during harvest further reduced yields and increased harvesting and post-harvest costs due to wet field conditions.

On the other hand, most conventional fields had not yet been sown at the time of the flooding, either due to delayed operational practices or traditional timing preferences. Ironically, this delay worked in their favour, allowing these fields to avoid the direct impact of the flood and proceed with sowing once conditions improved. This resulted in less disruption, lower additional costs, and consequently higher index scores for climate impact resilience.

II. Comparative Analysis of WPII of Climate-Resilient and Conventional Paddy Cultivation in Kerala

Table 4.57. Weather pattern impact Index values of Climate- Resilient and Conventional paddy cultivation (Values are Mean ± SD)

District	Climate resilient field	Conventional field
Alappuzha	7.00 ± 1.76	6.42 ± 0.86
Kottayam	6.50 ± 0.87	4.50 ± 1.41
Palakkad	9.14 ± 0.95	9.00 ± 0.77
Thrissur	7.11 ± 1.69	8.75 ± 0.61

Climate-resilient fields demonstrated greater operational stability under climatic variability. The protocol emphasized efficient drainage, and weather-resilient scheduling of inputs and operations. As a result, delays due to unexpected rainfall or dry spells were minimized to under 3 days, scoring high on the delay sub-index. Additionally, resilient crop stands and timely operations reduced extra expenditures even during erratic weather events. Conventional systems were more vulnerable—delays extended beyond a week in many cases, and unplanned reapplications of inputs due to rain damage or pest resurgence increased costs. This translated into lower WPII scores, signaling greater climate vulnerability.

II. District wise comparison of Weather Pattern Impact Index

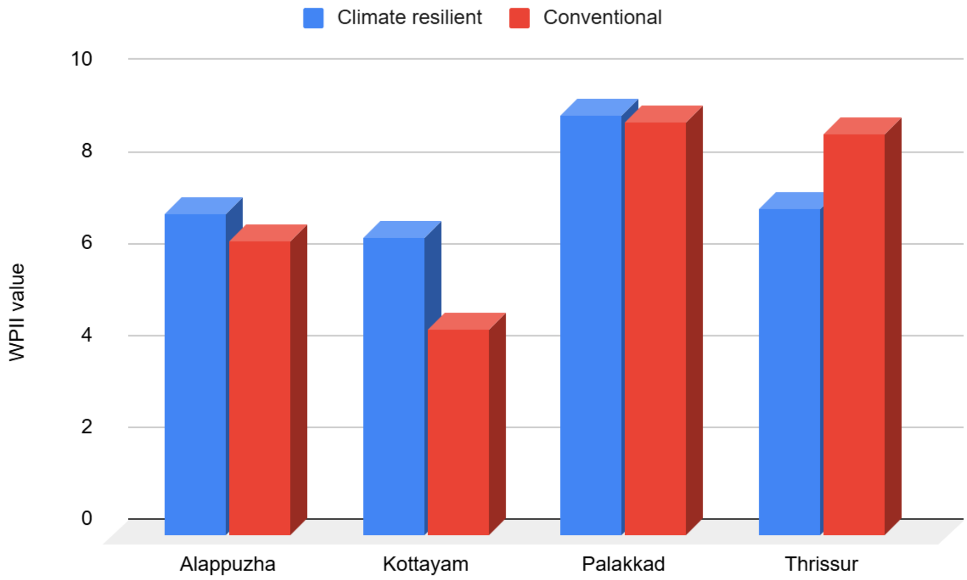


Fig 4.51. Weather pattern impact index among Climate-Resilient and Conventional paddy fields in key paddy growing districts of Kerala

The performance of paddy farming systems under climate stress varied notably across the four districts, reflecting differences in geography, timing of operations, and effectiveness of climate-resilient practices. Palakkad stood out for its consistently high WPII scores in both farming systems, indicating strong overall preparedness and minimal climate-related disruptions. The timely scheduling of cultivation ensured that weather events like summer showers had negligible impact, making Palakkad the most uniformly resilient district.

In contrast, Alappuzha, with its low-lying Kuttanad terrain prone to flooding, showed moderate WPII scores. Here, the climate-resilient fields had a clear advantage, due to mechanized sowing and protocol-based crop management. However, the area still faced significant challenges from early rains and delayed sowing, affecting both systems to varying degrees.

Kottayam recorded the widest gap in WPII scores between the two systems, with climate-resilient fields significantly outperforming conventional ones. Despite setbacks in one field due to late sowing, timely operations and proactive management in other climate-resilient plots helped mitigate weather-related disruptions. In contrast, conventional fields faced delays, higher input costs, and showed limited adaptability, contributing to their lower overall resilience scores. Thrissur, uniquely, presented an inversion of the expected trend. Conventional fields scored higher due to a peculiar sequence of events—severe early-season floods affected the climate-resilient fields that had been sown on schedule, while conventional plots benefited unintentionally by delaying their sowing until after the floods. This anomaly highlights how timing, more than technique, can sometimes play a decisive role in climate resilience, especially under unpredictable weather patterns.

IV. Findings

- Across the districts, climate-resilient paddy fields generally outperformed or matched conventional fields in the Weather Pattern Impact Index, except in Thrissur.
- In Palakkad, both climate-resilient and conventional systems showed high resilience, mainly due to well-timed sowing and harvesting. However, conventional plots incurred slightly higher pest management costs.
- In Alappuzha, climate-resilient fields recorded a higher WPII despite early-season flooding in the Kuttanad region, as farmers followed improved sowing techniques and strict protocol adherence.
- Kottayam showed the most significant difference between systems, with climate-resilient fields scoring 6.50 and conventional fields scoring 4.50, mainly due to better preparedness and effective mitigation of climate risks.
- Thrissur was the exception to the general trend, where conventional fields achieved a higher WPII. This was because climate-resilient plots were affected by severe flooding, having been sown earlier, while delayed operations in conventional fields helped them escape the worst of the damage.
- These inter-district differences emphasize the overall benefits of climate-resilient practices, while also highlighting the need for region-specific planning and flexible strategies to cope with local climate variability.

4.3.7. Changing Patterns of Farmer Involvement in Paddy Cultivation

A key insight from the field survey is the growing disconnect between land-owning farmers and their direct participation in cultivation activities. While many farmers retain legal ownership and claim affiliation with farming, actual field operations are increasingly delegated to hired labourers or contract groups. This reflects a broader trend of paddy cultivation transitioning into a managed economic enterprise, rather than a hands-on livelihood rooted in experiential knowledge.

This shift is driven by multiple factors—aging farming populations, youth migration, limited profitability, and the convenience of outsourced labour.As a result, farmers are becoming less connected to the land and are losing practical knowledge about crop management, which affects their ability to farm sustainably and adapt to climate challenges.

The extent of this shift was assessed by surveying the proportion of actual farmers directly involved in cultivation across both CRF and CF fields in four districts. The findings are as follows:

Table 4.58. Percentage of active farmers directly involved in paddy cultivation

District	Climate-Resilient Field(%)	Conventional Field(%)
Alappuzha	67	67
Palakkad	68	50
Kottayam	0	67
Thrissur	80	83

The data highlights sharp district-level differences in farmer involvement:

- In Alappuzha, 67% of farmers surveyed were directly involved in cultivation practices in both climate resilient and conventional fields, despite the region's difficult waterlogged conditions. This reflects a continuing reliance on community-based cultivation practices in Kuttanad.
- Palakkad shows a drop-off in conventional plots, where only half of the farmers were personally engaged, compared to 68% in CR fields. This suggests that institutional interventions and support under climate-resilient systems may be encouraging greater involvement.
- In Kottayam, a notable contrast emerges: while 67% of farmers in conventional fields were directly engaged in cultivation, none of the surveyed farmers in climate-resilient fields participated personally. This trend is primarily attributed to the older age profile of CR farmers and their engagement in other occupations. However, many of them remain indirectly involved—driven by a sustained interest in farming—by coordinating activities, providing inputs, and closely monitoring field operations through hired or collective labour.
- In Thrissur, the highest levels of farmer engagement were observed—over 80% in both CRF and CF plots—indicating a relatively strong agrarian base and sustained farmer presence in field operations.

This decline in active participation has several implications:

- Loss of experiential knowledge and adaptive decision-making, particularly in climate-sensitive environments.
- Weak implementation of sustainability protocols, when field operations are delegated to labourers unfamiliar with precise practices.
- Challenges for extension systems, as services like advisories, pest alerts, or soil health monitoring depend on farmer presence and participation.
- Reduced responsiveness to climate variability, since the absenteeism of landowners delays adaptive action during stress periods.

These findings highlight a critical shift in Kerala's paddy sector. While land remains with traditional owners, actual cultivation is increasingly done by others. This disconnect weakens the impact of sustainability schemes. Going forward, it is essential to ensure that all those involved in farming, whether owners or hired labourers, are trained, accountable, and actively engaged in climate-resilient practices.

This structural transformation in farming raises another critical concern—the future of paddy cultivation itself. As older generations withdraw from active farming and more landowners opt for hired labour, the sector faces a growing gap in generational continuity.

4.3.8. Declining Youth Participation in Rice Farming

A major finding of the study is the alarming decline in youth participation in paddy cultivation.which threatens the long-term sustainability of rice farming in Kerala. Despite numerous policy interventions, the next generation is largely absent from the sector, with very few young individuals expressing interest in continuing traditional farming practices.

Survey data collected from individual farmers across four districts revealed minimal to no youth involvement in paddy cultivation. Notably, no youth participation was recorded among surveyed farmers in Alappuzha and Kottayam. In Palakkad, only 1% of the farmers surveyed were from the youth category, while Thrissur showed the highest—but still marginal—youth participation at 13%.

Table 4.59. Youth participation in paddy cultivation (among surveyed individual farmers)

District	% of Youth Farmers (among total surveyed farmers)
Alappuzha	0
Kottayam	0
Palakkad	1
Thrissur	13

This pattern reflects a broader structural crisis, where paddy cultivation is increasingly viewed by the younger generation as economically unviable, labour-intensive, and disconnected from modern career aspirations. The lack of role models, limited access to land, high entry barriers, and absence of targeted incentives further discourage youth involvement.

Without serious efforts to re-engage youth in rice farming—through technology integration, agri-entrepreneurship models, skill-building, and attractive income pathways—the future of Kerala's paddy sector will remain uncertain. This calls for urgent policy attention, both to secure generational continuity and to inject innovation into a sector that is foundational to the state's food and ecological security.

4.3.9. Emotional Continuity Amid Economic Transition

While paddy cultivation in Kerala is increasingly treated as an economic enterprise, with many farmers delegating day-to-day operations to hired labour or external agencies, the decision to continue cultivation is often driven by deeper emotional and cultural factors. Findings from the field survey reveal that a significant majority of farmers remain committed to rice farming not for profit, but because of a strong ancestral legacy and a sense of obligation toward inherited land.

In all four study districts—Alappuzha, Palakkad, Kottayam, and Thrissur—almost all respondents cited tradition as the primary reason for continuing paddy cultivation. In Palakkad, a small proportion (5%) reported that their motivation was to prevent the land from lying fallow, rather than traditional ties. These responses reflect a strong emotional connection to rice farming, despite the economic challenges associated with it.

Table 4.60. Primary reasons for continuing paddy cultivation

District	Climate-Resilient Fields	Conventional Fields
Alappuzha	100% Traditional Motivation	100% Traditional Motivation
Palakkad	95% Traditional, 5% To Avoid Fallow	100% Traditional Motivation
Kottayam	100% Traditional Motivation	100% Traditional Motivation
Thrissur	100% Traditional Motivation	100% Traditional Motivation

Although farmers continue to cultivate rice, the vast majority now rely on alternative sources of income such as salaried employment, remittances, or small-scale business activities. As a result, paddy farming has become a secondary activity—often symbolic—sustained more by cultural continuity than by economic viability.

Despite cultivating rice, many farmers do not consume their own produce. This is influenced by a cultural shift toward polished or branded rice, lack of on-farm or in-house processing facilities, and easy access to subsidized rice through the Public Distribution System (PDS). In many cases, the rice is entirely sold through procurement channels, and without immediate need or means to process it, farmers opt to purchase rice separately for consumption.

This dual reality—where tradition sustains cultivation, but day-to-day farming is increasingly detached from the farmer—reflects a structural shift in the identity and function of rice cultivation in Kerala. Recognizing and addressing this transition is essential. While emotional commitment has helped preserve paddy landscapes, long-term sustainability will depend on strengthening economic, institutional, and ecological incentives that encourage active engagement and attract younger generations to the sector.

4.3.10. Constraints in Straw Recovery Due to Climatic and Field Conditions

Paddy straw, though often treated as a secondary product, plays a vital role in the farming system—serving as a source of livestock fodder, organic compost, and material for rural applications. However, field-level observations across the four surveyed districts revealed that straw recovery during the harvest phase was severely constrained, primarily due to climatic and field-related factors.

In Alappuzha and Kottayam, none of the surveyed farmers were able to recover usable straw. The primary constraint was unseasonal or continuous rainfall coinciding with the harvest period. High field moisture led to rapid decomposition of straw, rendering it unsuitable for collection or use.

In Palakkad and Thrissur, where harvesting conditions were somewhat more favourable, only 18% and 19% of farmers, respectively, reported successful straw recovery.

Table 4.61.Percentage of farmers received usable straw at harvest

District	Farmers Recovered Straw (%)
Alappuzha	0
Kottayam	0
Palakkad	18
Thrissur	19

Fig 4.52. Straw collection in Palakkad

This limited straw recovery can be attributed to a combination of weather and field conditions. In many cases, unseasonal or continuous rainfall during the harvest period led to high-moisture conditions that caused rapid decomposition of straw. Additionally, delayed harvesting—often due to equipment availability or labour issues—resulted in straw degradation or breakage, making collection unfeasible.

Lodging, where the crop falls over before harvest due to rain or wind, also contributed to straw loss, especially when combined with wet and slushy field conditions typical of Kerala's lowland paddy systems. These factors collectively made straw collection impractical in several fields despite an otherwise good grain harvest.

By documenting these operational challenges, the survey provides a clearer understanding of the dynamics affecting by-product utilization in rice farming and reinforces the importance of site-specific adjustments in field management practices.

4.3.11. Comparative Analysis of Total Post-Harvest Cost Across Districts

The total post-harvest cost per acre is a crucial indicator of the economic burden faced by farmers after harvest, directly impacting net income and profitability. This cost encompasses three major components—bagging and drying, transportation, and loading/unloading—all of which are shaped by local farming conditions, labor structures, yield levels, and post-harvest practices. The comparative data across Alappuzha, Palakkad, Kottayam, and Thrissur reveal marked variations in overall cost, highlighting both structural efficiencies and systemic challenges unique to each region.

Table 4.62. Total post-harvest cost across districts

District	PH Cost (AVG)/acre (in Rs)
Alappuzha	6,315
Palakkad	2,501
Kottayam	1,376
Thrissur	2,485

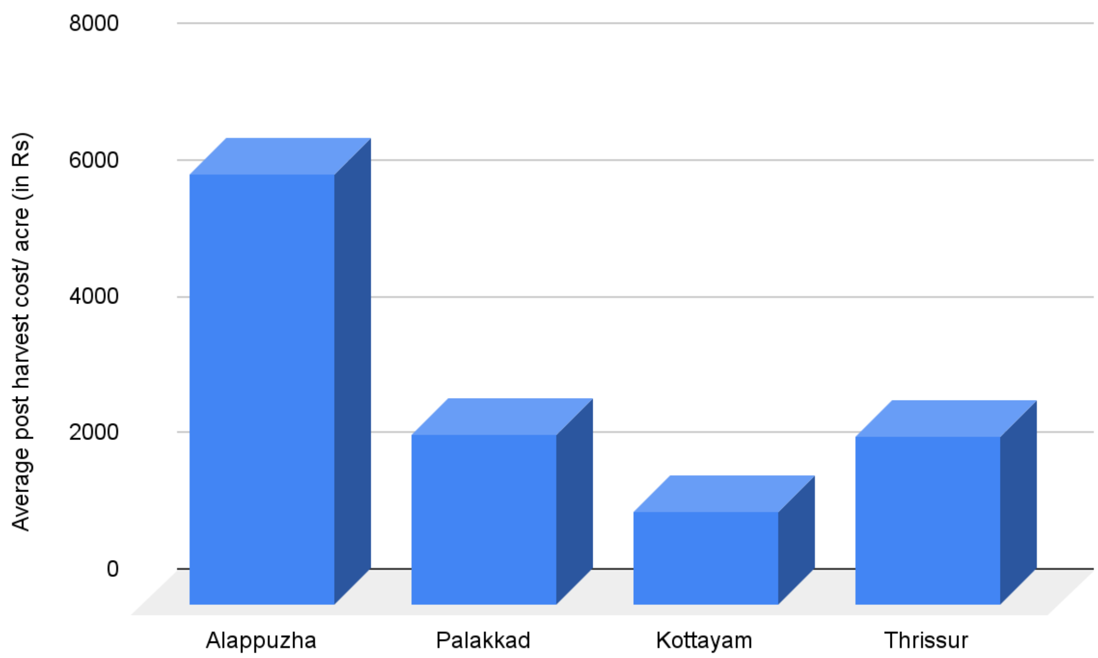


Fig 4.53. Total Post-Harvest Cost Across Districts

Alappuzha reported the highest total post-harvest cost, averaging ₹6,315 per acre. This figure is largely driven by the high expenditure on loading and unloading operations, which are charged at ₹120 per quintal and scale directly with yield. With harvest outputs frequently ranging between 26 to 31 quintals per acre, the labor cost alone constitutes a major portion of the total expenditure. Additionally, transportation costs in Alappuzha remain high due to logistical constraints and reliance on hired services. However, the district's bagging and drying costs are comparatively low, as in-field drying and direct bagging practices reduce the need for extended post-harvest labor. Despite this, farmers in Alappuzha face a standardized moisture deduction of 3 kg per quintal from their total recorded yield, primarily due to the in-field drying process. While this method saves on formal drying costs, the benefit is often offset by yield loss during procurement, as moisture-related deductions effectively reduce net returns. This challenge is further aggravated when rainfall occurs immediately after harvest, significantly impacting the drying process and increasing moisture content in the harvested grain. As a result, the high overall cost in Alappuzha reflects not only the success of high-yielding fields but also the burden of yield-linked labor charges under a per-quintal payment model, compounded by post-harvest moisture deductions and weather-related risks.

Palakkad, in contrast, reported a significantly lower total post-harvest cost at ₹2,501 per acre. The major contributor to this moderate cost profile is its low transportation expense, enabled by good road infrastructure and proximity to mills. Although bagging and drying costs in Palakkad are the highest among the four districts—due to longer drying periods and daily wage-based labor engagement—loading and unloading costs are controlled, as payments are made per sack and handling is relatively efficient. Importantly, farmers in Palakkad conduct proper drying of paddy before procurement, which ensures compliance with moisture standards and eliminates the need for moisture-based yield deductions. This practice safeguards their gross returns, as no quantity is deducted from their recorded yield during procurement. Overall, this balance allows Palakkad to manage post-harvest expenditure effectively, despite the cost-intensive drying process.

Kottayam, with an average post-harvest cost of ₹1,376 per acre, recorded the lowest among the four districts. However, this figure must be interpreted with caution, as it reflects a mix of contrasting scenarios. In several cases, post-harvest operations were not carried out at all due to extremely low yields, sale of produce to third-party buyers outside formal procurement, or even unharvested fields. These outliers substantially reduced the district's average. Nevertheless, among farmers who harvested and followed standard procedures, labor charges—especially for loading and unloading—were comparable to Alappuzha at ₹120 per quintal. Additionally, farmers in Kottayam who entered the procurement system had to bear a moisture deduction of 7 kg per quintal from their recorded yield, primarily due to inadequate drying and high residual moisture at the time of procurement. Post-harvest rainfall further worsened the scenario, making it difficult for farmers to reduce grain moisture levels before procurement. This significant deduction further impacted their net returns, despite the seemingly low average post-harvest cost. Therefore, while the district-wide expenditure appears minimal, it masks the financial burden faced by farmers who completed the harvest and engaged in formal procurement.

Thrissur reported a total average cost of ₹2,485 per acre, closely comparable to Palakkad. Its strength lies in highly efficient transport and labor arrangements. The district benefits from excellent road connectivity, allowing procurement trucks to reach fields directly, resulting in zero transport costs for most farmers. Like Palakkad, loading and unloading charges are paid per sack, which limits escalation in handling expenses. Bagging and drying costs are moderate, because of relatively quick drying cycles and fewer labor days required. However, despite completing field-level drying, farmers in Thrissur still had to bear a moisture deduction of 5 kg per quintal during procurement, primarily due to strict quality checks and minor variations in residual moisture. This deduction reduced the final recorded yield, slightly offsetting the benefits of their efficient post-harvest process. The overall cost profile of Thrissur, therefore, reflects operational efficiency supported by infrastructure and streamlined logistics, but with some loss at the procurement stage due to moisture penalties.

In addition to physical post-harvest challenges, farmers entering the government procurement process often face limited bargaining capacity. As prices are pre-fixed and procedures are standardized, farmers have minimal scope to negotiate rates or adjust to market fluctuations, which affects overall profitability despite production gains.

4.3.11.1. Comparative Analysis of Three Major Components of Post-Harvest Costs Across Districts

Post-harvest operations represent a critical stage in the rice production value chain, directly influencing profitability, grain quality, and market readiness. The analysis of costs associated with key post-harvest activities—namely bagging and drying, transportation, and loading/unloading—across the districts of Alappuzha, Palakkad, Kottayam, and Thrissur reveals notable spatial disparities shaped by agro-ecological conditions, infrastructural access, and labor dynamics.

I. Bagging and Drying Cost

Table 4.63. Bagging and drying cost across districts

District	Average cost/acre (in Rs)
Alappuzha	979
Palakkad	2,623
Kottayam	237
Thrissur	1,659

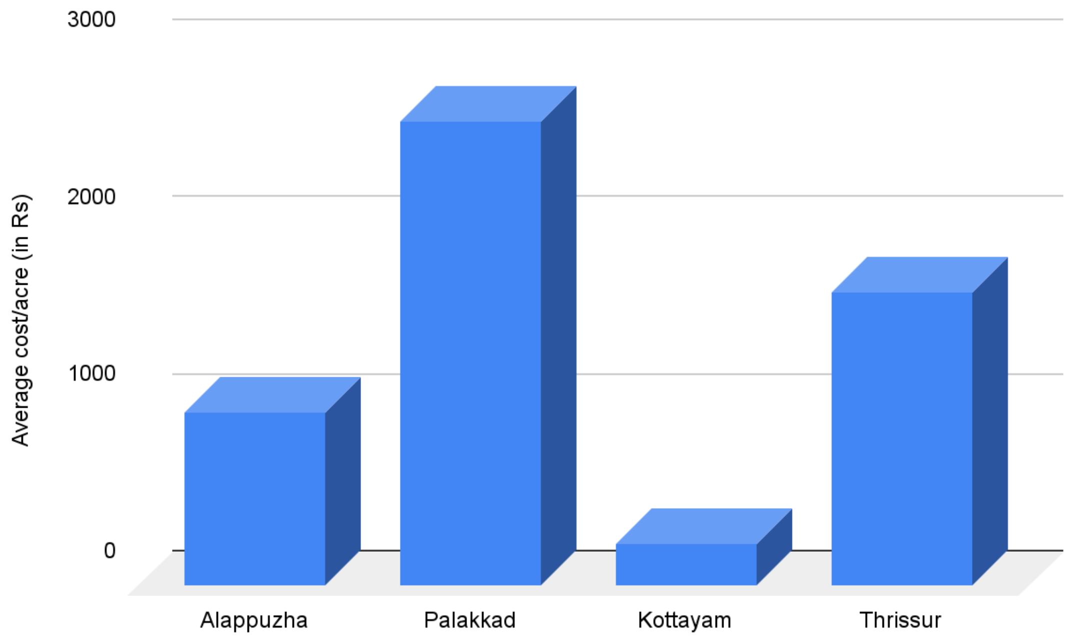


Fig 4.54. Bagging and drying cost across districts

Alappuzha reported a much lower cost of ₹979 per acre. This was largely due to the traditional practice of drying the paddy directly in the field itself immediately after harvest, particularly common in the Kuttanad region where large open fields and favorable post-harvest weather support in-field drying. As a result, the additional step of transferring produce to separate drying platforms or yards was avoided, reducing both labor requirements and overall expense. Bagging was done on-site, directly from the drying floor, further streamlining the process and minimizing cost. However, despite these cost advantages, farmers in Alappuzha still face a moisture deduction of 3 kg per quintal during procurement, since in-field drying often leaves minor moisture variations that do not meet strict procurement standards.

Palakkad reported the highest average cost for drying and bagging at ₹2,623 per acre. This is primarily due to the longer duration required for drying and bagging. Farmers in the region usually ensure that the produce meets the required moisture standards before handing it over to the procuring agency. However, local weather conditions and staggered labor availability often extend the drying process. Since labor is hired on a daily wage basis, this prolonged timeline results in increased costs. Despite the higher expense, Palakkad farmers benefit from proper drying practices, and no moisture deduction is imposed during procurement, ensuring full credit for the harvested quantity.

Kottayam registered the lowest average cost at ₹237 per acre. However, this figure reflects certain exceptional cases where post-harvest activities were either minimal or entirely bypassed. In some fields, produce was not routed through the official procurement system—which generally requires standardized drying and bagging—but was instead sold directly to private buyers who did not impose such requirements. In other cases, post-harvest operations were not carried out at all due to extremely low yields or complete crop failure, which naturally resulted in no associated costs for drying or bagging. Among the farmers who did engage in formal procurement, a significant moisture deduction of 7 kg per quintal was imposed due to insufficient drying, severely impacting net returns despite the low post-harvest expenditure.

Thrissur, with an average cost of ₹1,659 per acre, incurred relatively lower expenses than Palakkad. Unlike in Palakkad, farmers in Thrissur did not aim to achieve the required moisture level before handing over the produce. This reduced the time and labor needed for drying and bagging, thereby lowering costs. However, the procuring agency applied a moisture deduction of 5 kg per quintal due to higher residual moisture in the paddy, effectively offsetting the apparent savings from reduced drying expenses.

Fig 4.55. On-field drying in Alappuzha

Fig 4.56. Drying in Palakkad

Fig 4.57. Bagging in Palakkad

II. Transportation Costs

Table 4.64. Transportation costs across districts

District	Average cost/acre (in Rs)
Alappuzha	1,703
Palakkad	159
Kottayam	226
Thrissur	0

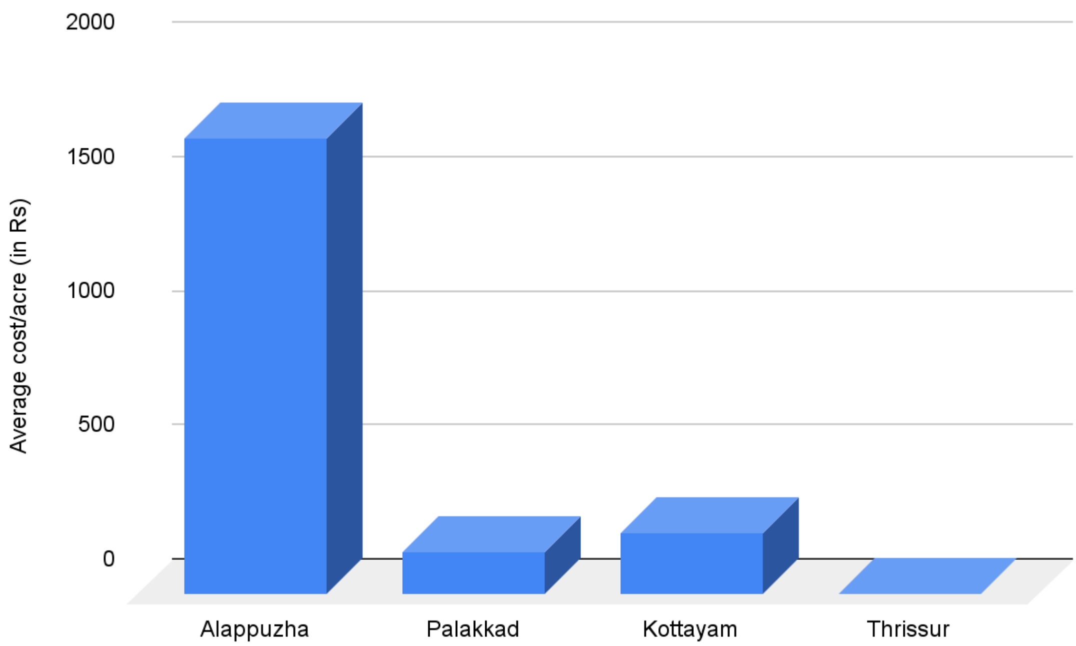


Fig 4.58. Transportation costs across districts

In Alappuzha, transportation costs averaged ₹1,703 per acre, the highest among the four districts. This is primarily due to the region's unique geography, especially in the Kuttanad area, where paddy fields are spread across low-lying, waterlogged tracts. These fields often lack direct road access, requiring produce to be manually carried over bunds or loaded into country boats for initial movement. The multiple stages of handling and the requirement to transfer the produce between different modes of transport before reaching motorable roads significantly increase both labor and transportation expenses. Additionally, the fragmented nature of holdings in Alappuzha often makes coordinated or bulk transportation unviable, further inflating per-unit costs.

Palakkad, in contrast, reported the lowest transportation cost at ₹159 per acre. This is indicative of well-developed road access and relatively larger contiguous landholdings. Farmers in Palakkad are often able to directly transport their produce using shared tractor trolleys or hired trucks with minimal travel distances, reducing both time and cost.

In Kottayam, the average transportation cost was ₹226 per acre, but this figure is shaped by atypical field realities rather than purely logistical expenses. In several cases, transportation was not undertaken at all, either because fields were left unharvested due to poor crop performance or because the harvested produce was sold to third-party buyers who did not require formal bagging, drying, or delivery through official procurement channels. Since post-harvest activities were minimal or skipped altogether in these situations, associated transport expenses were also avoided. Thus, the lower cost does not reflect greater efficiency, but rather a divergence from the typical post-harvest pathway due to low yield or alternative market arrangements. In cases where transportation did occur, challenges such as narrow access paths and scattered landholdings added complexity to the process, albeit on a smaller scale.

In Thrissur, the reported transportation cost was ₹0. This is not due to a lack of transport needs but reflects a well-structured and efficient logistical setup. Paddy fields in Thrissur are generally well-connected by roads, allowing trucks and procurement vehicles to reach directly up to the field edge during harvest. In many cases, produce is collected directly from the fields by millers or procurement agencies, thereby eliminating the need for farmers to arrange or pay for transportation themselves. This seamless last-mile connectivity, supported by both infrastructure and procurement arrangements, ensures minimal logistical burden for farmers in the district.

Fig 4.59. Transportation in Kottayam

III. Loading and Unloading Costs

Table 4.65. Loading and unloading costs across districts

District	Average cost/acre (in Rs)
Alappuzha	3,634
Palakkad	1,032
Kottayam	913
Thrissur	826

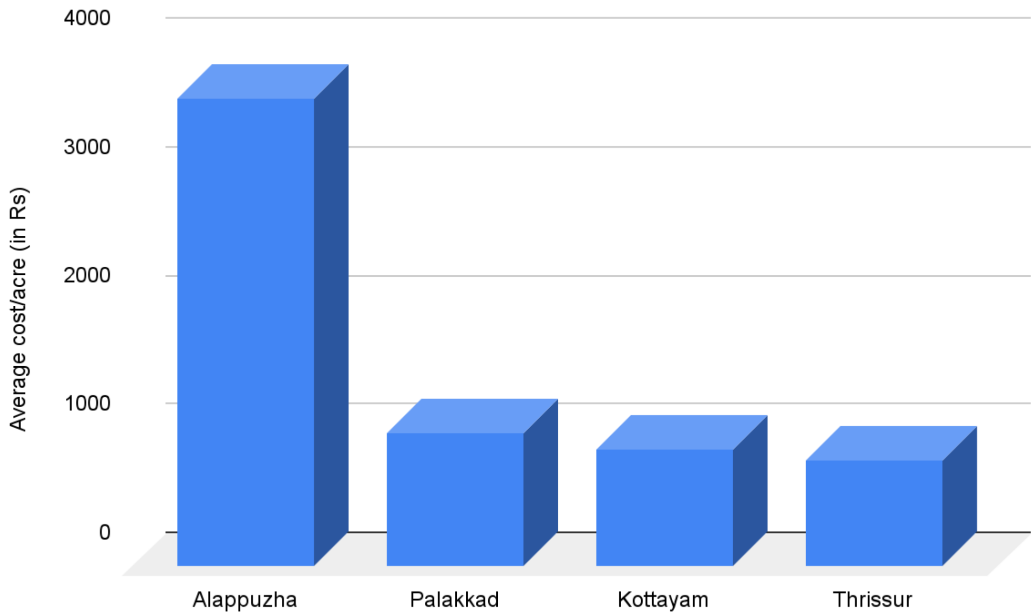


Fig 4.60. Loading and unloading costs across districts

In Alappuzha, the average loading and unloading cost was the highest at ₹3,634 per acre. This is primarily because labor is paid at a standard rate of ₹120 per quintal. With yields commonly ranging between 26 and 31 quintals per acre, the high harvest volume directly translated into higher labor costs. Since payment is calculated based on the total quantity of produce handled, even without additional complications in the handling process, the sheer scale of yield led to a substantial rise in costs. This pricing structure, while reflecting high productivity, results in a significant financial outlay during the post-harvest phase.

Palakkad recorded an average cost of ₹1,032 per acre. The district follows a ₹25 per sack payment norm, but the slightly higher cost suggests a greater number of sacks handled due to marginally higher yields. Despite standardized wage rates, variations in post-harvest practices between localities can influence the total cost. Still, compared to Alappuzha, the per-unit cost remains more controlled because it scales with bags handled rather than overall weight.

In Kottayam, the average cost stood at ₹913 per acre. While this may appear modest, it masks considerable internal variation. As mentioned in earlier sections, some farmers in Kottayam did not carry out full post-harvest processing due to either very low yield or opting out of formal procurement, which reduced their overall costs. However, it is also important to note that among those who harvested and followed standard post-harvest procedures, the labor charge was ₹120 per quintal—similar to Alappuzha. For these farmers, especially those with reasonably good yields, the cost of loading and unloading rose significantly. Thus, while the district average remains lower than Alappuzha's, it includes both farmers with minimal harvest and expenditure, as well as those who bore costs comparable to the highest levels observed in the study.

In Thrissur, the average cost was much lower at ₹826 per acre. Laborers in this district are typically paid ₹25 per sack, rather than per quintal. As a result, total loading and unloading expenses are tied to the number of bags packed, which is influenced by both the yield and the size of each unit. Thrissur's moderate yields and relatively efficient post-harvest systems help keep the number of sacks manageable, thereby containing costs. The consistent wage structure and smooth field-to-vehicle operations allow farmers to complete loading with limited labor input, keeping overall expenditure low.

Fig 4.61. Loading in Thrissur

4.3.11.2. Post Harvest Cost Variability and Operational Patterns

The comparative analysis of total post-harvest costs per acre across Alappuzha, Palakkad, Kottayam, and Thrissur highlights critical variations influenced by multiple factors, including yield levels, labor remuneration systems, infrastructural access, and post-harvest practices. Alappuzha incurred the highest costs, primarily due to high-yielding fields coupled with a per-quintal labor payment system for loading and unloading, and elevated transportation expenses arising from geographic constraints. While the district benefited from reduced bagging and drying costs through in-field drying, this advantage was offset by standardized moisture deductions during procurement, particularly exacerbated by post-harvest rainfall that complicated drying efforts and increased grain moisture content.

Palakkad maintained a balanced cost structure, recording the highest expenditure in bagging and drying due to longer drying periods and daily wage-based labor payments, yet benefiting from controlled transportation and handling costs facilitated by better road connectivity and per-sack labor models. Importantly, Palakkad farmers avoided procurement deductions by ensuring compliance with moisture standards.

Kottayam exhibited the lowest average post-harvest cost; however, this figure masks underlying disparities. In several cases, minimal or no post-harvest operations were conducted due to crop failure, low yields, or sales to private buyers outside formal procurement channels. Among farmers who did participate in procurement, inadequate drying combined with post-harvest rainfall led to significant moisture deductions, reducing net returns despite the low-cost average.

Thrissur showcased an efficient post-harvest system, with the lowest costs for transportation and handling due to direct field-to-truck access and per-sack labor arrangements. However, despite field-level drying, minor moisture deductions were still applied during procurement due to residual moisture content.

Overall, the findings emphasize that region-specific factors such as labor payment methods, procurement logistics, and climatic conditions significantly influence post-harvest cost structures. These insights are critical for informing targeted policy interventions aimed at reducing post-harvest economic burdens and enhancing the profitability of rice cultivation across diverse agro-ecological regions.

4.4. CONCLUSION

Climate-resilient paddy farming interventions were implemented and evaluated using a structured protocol tailored to the agro-ecological and socio-economic conditions of the study areas. The project followed a participatory approach, beginning with extensive farmer orientation workshops that facilitated the identification of region-specific challenges and enabled the localization of the protocol. During the implementation phase, the climate-resilient farming protocol was adopted across 360.95 acres, managed by 69 participating farmers. Comparative data were collected from 381.7 acres of conventional fields. Adoption levels were influenced by field-specific factors, including crop duration, seed quality, and local farming traditions.

The project faced multiple implementation constraints. Key limitations included poor access to inputs like seed drums, Trichocards, and machinery, high rental costs for equipment, lack of proper drainage infrastructure, and farmer hesitancy to shift from traditional methods. These barriers restricted full compliance in certain locations.

A structured field monitoring system—including direct visits, Project Management Committee meetings, telephonic interviews, and WhatsApp-based advisory groups—ensured real-time support to farmers. Monitoring activities helped capture operational deviations, input usage, pest and disease emergence, and labor deployment patterns.

The assessment of compliance with the protocol showed encouraging adoption levels, with climate-resilient Samithis achieving more than 50% adherence across districts, compared to 23% in conventional fields. Palakkad recorded the highest protocol adherence at 57%, while Thrissur, Alappuzha and Kottayam followed closely.

A multi-dimensional index evaluation system was employed to assess the effectiveness of interventions using five indices—RTI, CEI, YPI, AITI, and WPII. Palakkad recorded the highest scores in RTI, AITI, and WPII, reflecting safer input use, higher adoption of improved techniques, and better resilience to climate-related disruptions. Alappuzha achieved the highest scores in CEI and YPI, indicating superior cost efficiency and better yield performance in the climate-resilient fields.

The survey revealed a growing trend of land-owning farmers outsourcing cultivation activities to hired labor, with direct farmer participation varying across districts—67% in Alappuzha, 68% in Palakkad's CR fields (but only 50% in conventional plots), 0% in Kottayam's CR fields, and over 80% in Thrissur. This shift has led to the erosion of practical farming knowledge, weakened adoption of sustainability practices, and reduced capacity for climate-responsive decision-making.

The study revealed a critical decline in youth participation in paddy cultivation, with no involvement recorded in Alappuzha and Kottayam, and only minimal participation in Palakkad (1%) and Thrissur (13%). This trend reflects broader structural challenges, as rice farming is increasingly perceived by the younger generation as economically unviable, labour-intensive, and lacking modern career prospects.

Most farmers continue paddy cultivation not for profit but due to emotional and cultural attachments, primarily valuing tradition and ancestral legacy. In all four districts, nearly all respondents cited tradition as the main reason, with a small percentage in Palakkad (5%) motivated by the desire to prevent land from lying fallow. Despite this cultural continuity, rice farming has become a secondary activity for many, with most farmers relying on other income sources and often not consuming their own produce.

Straw recovery during paddy harvest was severely limited across the study areas due to climatic and field-related constraints. In Alappuzha and Kottayam, none of the farmers could recover straw because of unseasonal rains and high field moisture, while in Palakkad and Thrissur, only 18% and 19% of farmers, respectively, managed successful recovery. Factors such as rainfall during harvest, delayed harvesting, lodging, and slushy field conditions contributed to straw degradation and made collection largely unfeasible.

Finally, the post-harvest survey indicated substantial variation in costs across districts. Alappuzha reported the highest post-harvest expenses due to multiple handling stages, and labor shortages. In contrast, Palakkad and

Thrissur managed lower post-harvest costs due to better transport logistics and mechanization. In Kottayam, post-harvest cost data were not fully representative, as several farmers sold the harvested paddy directly to duck farmers, avoiding further post-harvest processing and cost accumulation. Farmers who undertook the full post-harvest process incurred higher expenses due to poor field access and prolonged drying due to rainfall after harvest.

In summary, the implementation of the Climate-Resilient Paddy Farming Protocol demonstrated both technical feasibility and farmer willingness for sustainable adoption. However, systemic challenges such as logistical barriers, input availability, technological shifts, post-harvest infrastructure, and generational gaps must be addressed to mainstream climate-resilient farming in Kerala's rice sector.

4.5. SUMMARY

- Climate-resilient paddy farming interventions were implemented using a structured protocol customized to local agro-ecological and socio-economic conditions through participatory engagement.
- Farmer orientation workshops facilitated region-specific customization, leading to adoption across 360.95 acres by 69 farmers, with comparative data collected from 381.7 acres of conventional fields.
- Field monitoring was conducted through direct visits, Project Management Committee meetings, telephonic follow-ups, and WhatsApp-based advisories, ensuring real-time support and data collection.
- Climate-resilient Samithis showed more than 50% adherence to the protocol, with Palakkad recording the highest compliance at 57%, followed by Kottayam (55%), Alappuzha (53%), and Thrissur (50%). This strong protocol adherence significantly contributed to the positive results observed. However, full compliance was constrained by limited access and availability of inputs, as well as water management challenges due to shared irrigation systems. Resistance to new technologies, mistrust in scientific protocols, low crop insurance participation, shortage of skilled labour, and weak collective decision-making in group farming further limited cooperation.
- In index-based evaluations, Palakkad scored highest in RTI, AITI, and WPII, reflecting safer input use, higher adoption of improved techniques, and better climate resilience, while Alappuzha scored highest in CEI and YPI, indicating superior cost efficiency and better yield performance.
- Farmers who adopted the protocol better achieved favourable outcomes across all indices, demonstrating the effectiveness of the climate-resilient model. Hence the proposed protocol has strong potential to enhance climate resilience, reduce input risks, and improve economic returns when implemented with adequate support and community-level coordination.
- A shift toward outsourcing cultivation was observed, with direct farmer involvement at 67% in Alappuzha, 68% in Palakkad's CR fields (50% in conventional plots), 0% in Kottayam's CR fields, and over 80% in Thrissur. Aging farmers, reliance on other jobs, youth migration, and dependence on hired labour have reduced direct farmer involvement in cultivation practices, leading to erosion of practical knowledge and weaker climate adaptability.
- Youth participation in paddy cultivation was critically low, with no notable involvement observed in Alappuzha and Kottayam. 1% in Palakkad, and 13% in Thrissur—raising concerns about generational continuity. Paddy cultivation is increasingly viewed by the younger generation as economically unviable, labour-intensive, and disconnected from modern career aspirations. High entry barriers, and absence of targeted incentives further discourage youth involvement.
- Most farmers continued rice cultivation due to cultural and ancestral ties rather than economic incentives; in all districts, tradition was the primary reason, with 5% in Palakkad motivated by the desire to prevent land from lying fallow. Emotion sustains the decision to continue, but execution is increasingly commercialized and detached.
- Straw recovery was severely limited by unseasonal rain, harvest delays, and lodging, leading to high moisture, breakage, and decomposition. Recovery was absent in Alappuzha and Kottayam, and minimal in Palakkad (18%) and Thrissur (19%). This resulted in significant

economic loss for farmers.

- Post harvest cost variation across districts was driven by differences in yield, labor charges, transport conditions, and drying methods. Alappuzha faced the highest costs due to high yields and difficult terrain, while Kottayam's low cost reflected poor returns. Thrissur was most efficient, and Palakkad maintained balance with controlled transport and effective drying.
- The project confirmed the technical feasibility and farmer willingness for sustainable adoption of the protocol but highlighted the need to address systemic barriers including logistical challenges, input access, post-harvest infrastructure, and declining youth participation for long-term sectoral sustainability.

CHAPTER 5
Carbon Sequestration Dynamics in Climate-Resilient and Conventional Rice Farming Systems

5.1. INTRODUCTION

Climate change is one of the most critical environmental issues facing the world today. The rapid increase in greenhouse gas concentrations, particularly carbon dioxide, has led to rising global temperatures, changes in precipitation patterns, sea level rise, and more frequent extreme weather events (IPCC, 2021). The United Nations Framework Convention on Climate Change identifies human activities such as fossil fuel burning, deforestation, and land use change as the primary drivers of climate change (UNFCCC, 2022). To address this growing threat, global agreements such as the Paris Agreement have set ambitious targets to limit global warming to well below two degrees Celsius, with an aim to pursue efforts to keep it below one point five degrees (UNFCCC, 2015). Achieving these goals requires not only reducing greenhouse gas emissions but also removing excess carbon dioxide from the atmosphere.

Carbon sequestration is a key strategy in this context. It refers to the process of capturing and storing atmospheric carbon dioxide in various natural or engineered systems (IPCC, 2022). The main forms of carbon sequestration include biological sequestration and geological sequestration. Biological sequestration involves the absorption of carbon dioxide by plants through photosynthesis, with the carbon subsequently stored in biomass, soils, and wetlands. Geological sequestration, on the other hand, involves the injection of carbon dioxide into underground rock formations for long-term storage.

Biological carbon sequestration is especially important because it harnesses the natural capacity of ecosystems to remove carbon from the atmosphere. Forests, grasslands, wetlands, and oceans act as significant carbon sinks, absorbing large amounts of atmospheric carbon and storing it over varying time scales (Lal, 2008). Among these, oceans—particularly through blue carbon, which refers to the carbon captured and stored by marine and coastal ecosystems like mangroves, salt marshes, and seagrass meadows—serve as the largest carbon sink, playing a crucial role in long-term carbon storage. Soil also plays a vital role in the global carbon cycle, storing more carbon than the atmosphere and all plant life combined (IPCC, 2022). In addition to mitigating climate change, carbon sequestration provides co-benefits such as improving biodiversity, enhancing soil fertility, supporting water conservation, and promoting ecosystem resilience (Smith et al. 2014). However, the effectiveness of carbon sequestration depends on proper management, long-term maintenance, and careful monitoring to prevent the release of stored carbon back into the atmosphere.

Given the global urgency to balance carbon emissions with carbon removal, carbon sequestration has emerged as a central focus in climate change mitigation policies and research. It serves as a complementary strategy alongside emission reductions, contributing to global efforts to stabilize the climate system.

5.1.1. Background

Carbon sequestration in agricultural systems plays a crucial role in mitigating atmospheric carbon dioxide while enhancing ecosystem productivity and soil health. In paddy cultivation, one of the most widespread and resource-intensive cropping systems in the world, there is significant potential not only to reduce greenhouse gas emissions but also to transform rice fields into effective carbon sinks. Traditionally, rice cultivation has been associated with methane emissions and carbon losses. However, the adoption of improved management practices can promote carbon storage both in the soil as Soil Organic Carbon (SOC) and in plant biomass as Above Ground Biomass Carbon (AGBC). Soil organic carbon contributes to long term soil fertility and microbial activity, while above ground biomass carbon reflects the carbon stored in the vegetative parts of the crop, serving as an indicator of crop productivity and short term carbon dynamics. Addressing both components of carbon storage is essential for developing sustainable and climate resilient rice farming systems that support food security and environmental sustainability.

5.1.2. Objective

The objective of this study is to assess the potential of a climate-resilient paddy farming protocol to enhance overall carbon sequestration, including both SOC and AGBC. The study aims to compare the carbon sequestration potential of climate-resilient practices against conventional methods across selected districts, using standardized sampling and analysis techniques to quantify carbon storage in both soil and plant biomass.

5.2. METHODOLOGY

5.2.1. Sampling

Soil and above-ground biomass samples were collected from both climate-resilient and conventional plots at different stages of the paddy crop cycle. Soil samples were collected at four critical stages: pre-sowing, 30 Days After Sowing (DAS), 60 DAS, and pre-harvest. At each stage, composite samples were prepared by collecting 3–5 subsamples from different points within each plot to ensure representativeness. Samples were taken from a depth of 15 cm, corresponding to the active root zone of paddy, and each sample weighed 1 kg. The collected soil samples were shade-dried and ground for further analysis.

Fig 5.1. Soil sampling in Alappuzha

Fig 5.2. Soil sampling in Palakkad

Fig 5.3. Soil sampling in Thrissur

Fig 5.4. Soil sampling in Kottayam

Above-ground biomass samples were collected at three crop stages: 30 DAS, 60 DAS, and before harvest. At each stage, multiple samples were collected from 1-square-meter areas at different sampling points within each plot. The collected biomass was then dried and weighed to estimate above-ground biomass carbon content.

Fig 5.5. AGB sampling in Kottayam

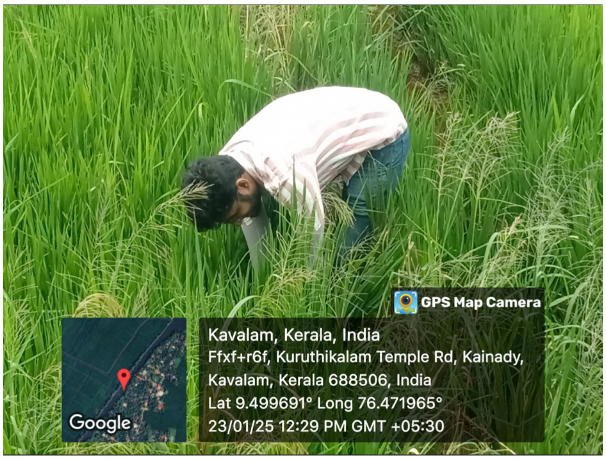


Fig 5.6. AGB sampling in Kottayam

Fig 5.7. AGB sampling in Thrissur

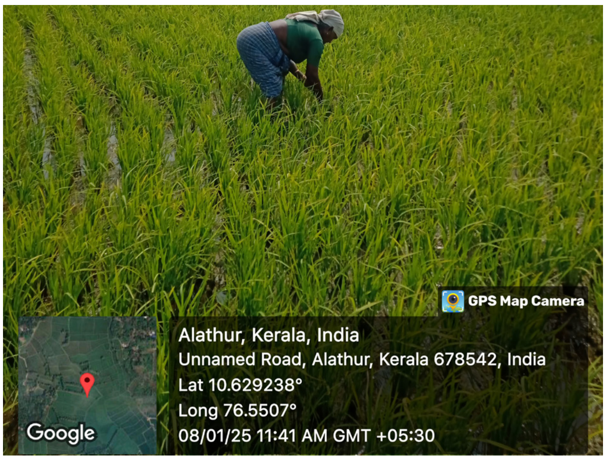


Fig 5.8. AGB sampling in Palakkad

Table.5.1. Sampling dates

District	Location Coordinates	Before sowing	30 DAS	60 DAS	Before harvest
		Date of sampling	Date of sampling	Date of sampling	Date of sampling
Alappuzha CRF	9°30'06.9"N 76°28'23.2"E 9°29'39.2"N 76°28'04.1"E 9°29'26.9"N 76°26'54.5"E 9°30'29.3"N 76°26'51.5"E	16/11/24	04/01/25	23/01/25	11/03/25
Alappuzha CF	9°30'27.8"N 76°28'17.4"E 9°30'42.3"N 76°26'41.9"E 9°31'38.5"N 76°26'34.5"E 9°31'41.2"N 76°28'43.2"E	16/11/24	07/01/25	10/02/25	13/03/25
Palakkad CRF	10°38'04.1"N 76°32'56.3"E 10°38'04.8"N 76°33'05.5"E 10°37'43.3"N 76°33'07.3"E 10°37'47.5"N 76°32'52.9"E	07/09/24	08/01/25	30/01/25	14/03/25
Palakkad CF	10°38'20.7"N 76°32'33.4"E 10°38'24.9"N 76°32'46.1"E 10°38'11.0"N 76°32'58.2"E 10°38'09.0"N 76°32'34.2"E	25/11/24	08/01/25	30/01/25	14/03/25
Thrissur CRF	10°13'31.1"N 76°18'18.0"E 10°13'31.7"N 76°18'40.6"E 10°13'43.8"N 76°18'33.3"E 10°13'45.1"N 76°18'22.5"E	19/12/24	31/01/25	20/2/25	14/04/25
Thrissur CF	10°13'23.4"N 76°18'12.3"E 10°13'20.7"N 76°18'37.5"E 10°13'09.9"N 76°18'41.5"E 10°13'06.5"N 76°18'24.5"E	19/12/24	31/01/25	20/2/25	14/04/25

	9°38’58.9”N 76°26’03.6”E 9°39’08.3”N 76°26’09.9”E	11/12/24	25/02/25		04/04/25
Kottayam-CRF	9°25’20.6”N 76°31’48.0”E 9°25’54.7”N 76°31’50.2”E	3/12/24	10/2/25	Sample collection at 60 DAS is not done since the variety is of short duration	18/03/25
	9°38’37.1”N 76°25’40.9”E 9°38’40.7”N 76°25’32.8”E	31/12/24	11/02/25		17/03/25
Kottayam- CF	9°25’54.7”N 76°31’47.3”E 9°25’42.1”N 76°31’48.4”E	28/11/24	28/12/25		18/03/25

Note: No above-ground biomass was collected before sowing. AGB and soil samples were collected on the same day at each sampling stage.

5.2.2. Carbon Estimation

SOC content was determined using the Walkley–Black method (Walkley & Black, 1934). SOC percentage was converted into tonnes of carbon per hectare (t C/ha) using corresponding bulk density values and sampling depth, allowing for an estimation of soil carbon sequestration at each crop growth stage.

AGBC was estimated by drying the harvested plant material to obtain the dry biomass weight. The carbon stock was then calculated using the formula:

Carbon stock (t C/ha) = Dry biomass (t/ha) × 0.5

Based on the standard assumption that approximately 50% of plant dry biomass is carbon (IPCC, 2006; Pearson et al. 2005).

5.2.3. Remote Sensing and Satellite-Based Biomass Estimation

In addition to field sampling, remote sensing data from LISS IV satellite imagery (Resourcesat series) were used to estimate field-level biomass. High-resolution multispectral images with a spatial resolution of 5.8 meters were obtained from the Indian Space Research Organisation’s (ISRO) Bhoonidhi portal (https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html). Cloud-free images were collected for pre-, during, and post-paddy cultivation periods across multiple acquisition dates.

5.2.3.1. Satellite Images Used

Table 5.2. Satellite image used for study

Sl.No	Satellite/Sensor	Date of Acquisition	Path/Row	Resolution
1	LISS IV/ Resourcesat	07/01/2025	100/67	5.8 m
2		09/02/2025	100/67	
3		28/02/2025	99/67	
4		18/03/2025	100/67	
5		04/04/2025	100/67	
6		01/01/2025	99/66	
7		06/02/2025	99/66	
8		28/02/2025	99/66	
9		28/03/2025	99/66	

5.2.3.2. Softwares Used

- ArcGIS 10.8
- QGIS 3.16.8
- Google EarthPro

5.2.4. Data Analysis

5.2.4.1. Field data analysis

The mean values of SOC and AGBC were calculated for each crop stage in both climate-resilient and conventional plots. To assess the statistical significance of differences between the two treatments at each stage, independent t-tests were performed. Differences were considered statistically significant at $p < 0.05$. Soil Organic Carbon Change was estimated by calculating the difference between the peak SOC stock at 30 DAS and the initial SOC stock recorded before sowing. Similarly, the Net Above-Ground Biomass Carbon Change was calculated by subtracting the AGBC at 30 DAS from the AGBC measured before harvest, indicating the total biomass carbon accumulated during the active growth phase.

5.2.4.2. Satellite-Based Biomass Estimation

Primary source of data is LISS IV satellite data from the Indian Space Research Organisation's (ISRO) Resourcesat-2. Cloud free-clear images of Multi-spectral IRS 1D LISS IV MX, with a resolution of 5.8 m will be collected for Pre, During and Post Paddy cultivation stages (Table 5.2).

The study integrates field inventory data with the satellite images. Analysis involves four major steps, namely, (i) Image processing, (ii) derivation of vegetation indices using satellite imagery (iii) ground truthing through field stratification and collection of field inventory data (iv) generating allometric equations and prediction of biomass of entire paddy field.

- All the LISS IV satellite images were downloaded from Bhoonidhi portal (https://bhoonidhi.nrsc.gov.in/bhoonidhi/home.html).
- Normalised Difference Vegetation Index was calculated for all images using the equation below (Eq.1)

$$NDVI = \frac{NIR-RED}{NIR+RED} \qquad \text{(Eq.1)}$$

- Field AGB was collected as per standard methodology. A total of 2 Plots (conventional and climate resilient) were inventoried on 4 locations.
- Calculated NDVI values were extracted from each output from the exact spatial Sampling points used for AGB estimation and were used for further estimations.
- Linear Relationships between NDVI and Biomass were estimated for all Sampling regions and for various stages also.
- The R^2 and the allometric equations were generated for each plot.
- Biomass for each location and each season was estimated using these allometric equations.

5.3. RESULTS

5.3.1. Soil Organic Carbon

SOC represents the largest terrestrial carbon reservoir, storing carbon primarily derived from decomposed plant and animal residues within the soil matrix. It's a critical component of soil health, influencing nutrient cycling, water retention, and overall soil fertility. Furthermore, agricultural soils have a significant potential to act as a carbon sink, sequestering atmospheric carbon dioxide and contributing to climate change mitigation efforts.

5.3.1.1. Soil Organic Carbon Stock Dynamics During the Cropping Season (Puncha/Second crop)

Soil organic carbon stock exhibited dynamic fluctuations across the cropping season and varied notably between districts and farming systems (Table 5.3, Figure 5.9.). While most systems showed an initial increase in SOC from Before Sowing to 30 DAS, a subsequent decline was commonly observed towards 60 DAS and Before Harvest, suggesting active carbon turnover. Notably, CRF in Palakkad and Kottayam demonstrated significantly higher SOC stocks at 30 DAS compared to CF, (Table 5.4). In Kottayam, this trend continued through to harvest, where the CRF also recorded significantly higher SOC (Table 5.4). Alappuzha and Thrissur presented more nuanced patterns, with Conventional Samithis occasionally showing comparable or higher SOC stocks at certain stages, however, these differences were not statistically significant.

Table 5.3. SOC stock (t C/ha) at different stages of the cropping cycle in various districts and farming systems

District	Farming System	Before Sowing	30 DAS	60 DAS	Before Harvest
Palakkad	CRF	13.16	71.74	31.32	10.8
	CF	14.25	18.9	15.66	2.03
Alappuzha	CRF	20.25	75.6	57.38	9.45
	CF	20.7	60.75	68.4	10.8
Kottayam	CRF	50.55	78.3	N/A	22.28
	CF	73.35	57.24	N/A	12.83
Thrissur	CRF	38.88	56.7	44.55	27.68
	CF	29.7	52.65	43.2	16.2

Note: In Kottayam, due to the short-duration (90 days) variety cultivated, only three samplings were conducted: Before Sowing, 30 DAS, and Before Harvest. The '60 DAS' column is marked 'N/A' (Not Applicable) for this district.

Table 5.4. Independent samples t-test results comparing SOC between climate-resilient and conventional paddy fields across districts

District	Stage	t-value	p-value	Significance
Thrissur	Before Sowing	-0.54	0.61	Not Significant
	30 DAS	0.70	0.52	Not Significant
	60 DAS	0.00	1.00	Not Significant
	Before Harvest	1.51	0.20	Not Significant
Palakkad	Before Sowing	-0.47	0.66	Not Significant
	30 DAS	3.36	0.02	Significant
	60 DAS	2.35	0.06	Marginal (p=0.06)
	Before Harvest	0.55	0.60	Not Significant
Alappuzha	Before Sowing	-0.21	0.84	Not Significant
	30 DAS	1.95	0.11	Not Significant
	60 DAS	0.43	0.69	Not Significant
	Before Harvest	0.43	0.68	Not Significant
Kottayam	Before Sowing	-1.11	0.38	Not Significant
	30 DAS	2.45	0.046	Significant
	Before Harvest	2.84	0.029	Significant

Level of significance: 5% ($p < 0.05$)

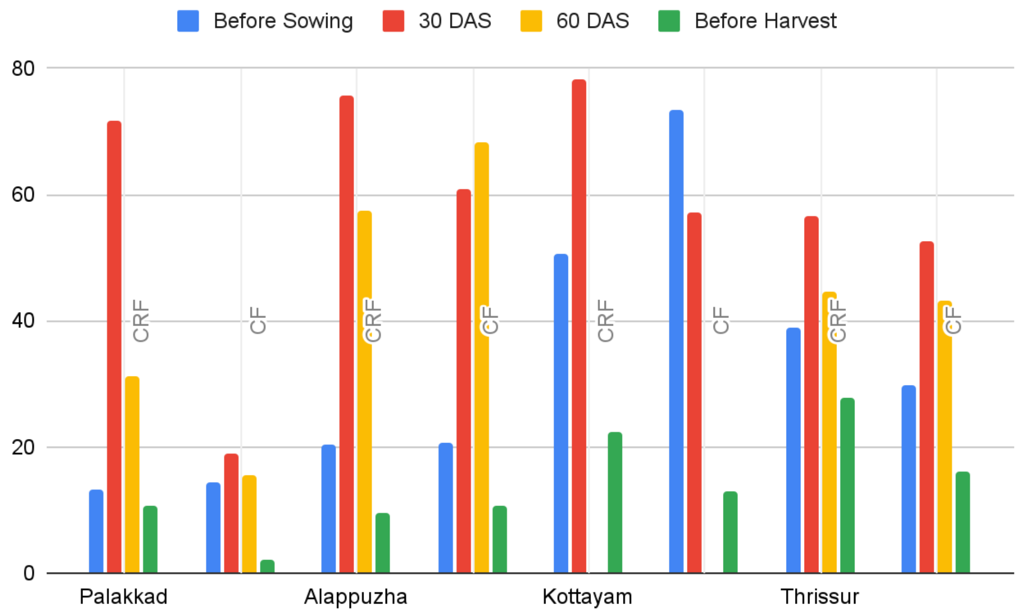


Figure 5.9. Temporal dynamics of SOC stock (t C/ha) across different districts and farming systems

Soil organic carbon stock exhibited dynamic fluctuations across the cropping season and varied notably between districts and farming systems (Table 5.3, Figure 5.9). While most systems showed an initial increase in SOC from Before Sowing to 30 DAS, a subsequent decline was commonly observed towards 60 DAS and Before Harvest, suggesting active carbon turnover. Notably, Climate Resilient fields in Palakkad and Kottayam demonstrated significantly higher peak SOC and overall better retention compared to Conventional Samithis, while Alappuzha and Thrissur presented more nuanced patterns, with Conventional Samithis occasionally showing comparable or higher SOC stocks at certain stages, particularly a high peak in Alappuzha Conventional.

5.3.1.2 Soil Organic Carbon Change

Soil Organic Carbon change was quantified by calculating the difference between the peak SOC stock observed at 30 DAS and the initial SOC stock recorded before sowing. This metric highlights the soil's capacity for rapid carbon accumulation during the crop's establishment and active vegetative growth phase. Table 5.4 summarizes these calculated Changes for each district and farming system.

Table 5.5. SOC change (t C/ha) (30 DAS peak vs. before Sowing) in different districts and farming systems

District	Climate Resilient Field (t C/ha)	Conventional Field (t C/ha)
Palakkad	58.58	4.65
Alappuzha	55.35	40.05
Kottayam	27.75	-16.11
Thrissur	17.82	22.95

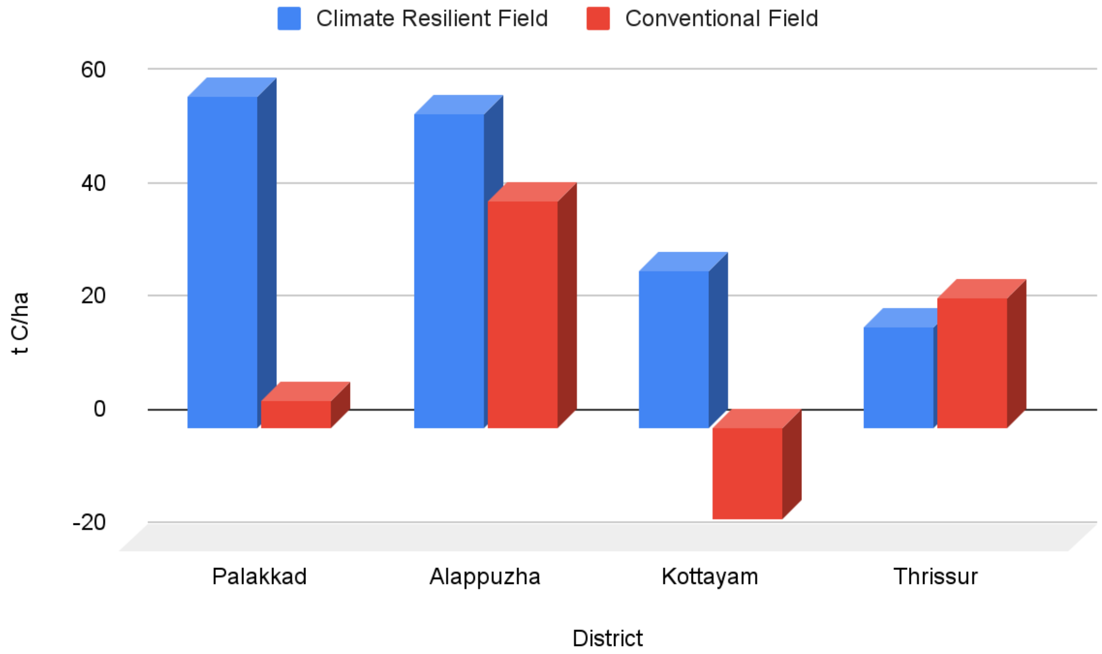


Figure 5.10. SOC (t C/ha) across different districts and farming systems

The analysis of SOC Change (Table 5.5, Figure 5.10) reveals distinct responses across the districts. Climate Resilient fields in Palakkad and Alappuzha exhibited the highest Changes, recording 58.58 t C/ha and 55.35 t C/ha respectively, significantly surpassing the Changes in their conventional fields. In Kottayam, the Climate Resilient field achieved a positive Change of 27.75 t C/ha, contrasting sharply with a notable loss of 16.11 t C/ha observed in the Conventional field during this period. Conversely, in Thrissur, the Conventional field showed a slightly higher Change of 22.95 t C/ha compared to the Climate Resilient field's 17.82 t C/ha, possibly due to the immediate rainfall-induced flood affecting the Climate Resilient field, while the Conventional field, sown later, managed to escape the flooding impact. These results highlight the varying capacities of different farming systems to rapidly accumulate carbon during the initial growth phase, with Climate Resilient practices showing particular strength in most of the regions.

5.3.2. Above-Ground Biomass Carbon

Above-Ground Biomass Carbon, refers to the carbon stored in the living plant material above the soil surface, including stems, leaves, and reproductive organs. Plants accumulate this carbon through photosynthesis, directly capturing atmospheric carbon dioxide and converting it into organic compounds. AGB is a direct measure of primary productivity and represents a temporary but significant carbon pool in agricultural systems, which, upon senescence and decomposition, can contribute to the SOC pool. Understanding the dynamics of both SOC and AGB carbon is crucial for assessing the overall carbon balance and sequestration potential of different farming systems.

5.3.2.1. Validation of Field Biomass with Satellite Data

Table 5.6. Trend of biomass estimated through field methods and digital image processing (Estimated biomass) at various sampling plots

Location	Coordinates	1st Sampling		2nd Sampling		3rd Sampling	
		Field Biomass (kg/sq.m)	Estimated Biomass (kg/sq.m)	Field Biomass (kg/sq.m)	Estimated Biomass (kg/sq.m)	Field Biomass (kg/sq.m)	Estimated Biomass (kg/sq.m)
Alappuzha – Climate resilient	9°30’06.9”N 76°28’23.2”E	0.28	0.560	0.56	0.8565	1.31	1.887
	9°29’39.2”N 76°28’04.1”E	0.56	0.540	0.85	0.8131	1.55	1.752
	9°29’26.9”N 76°26’54.5”E	0.42	0.534	0.70	0.8489	1.42	1.713
	9°30’29.3”N 76°26’51.5”E	0.71	0.557	0.69	0.7919	1.75	1.867
Average Trend		0.49	0.548	0.70	0.8276	1.51	1.805
Alappuzha - Conventional	9°30’27.8”N 76°28’17.4”E	0.79	0.562	0.95	0.6833	2.50	1.905
	9°30’42.3”N 76°26’41.9”E	0.69	0.535	0.71	0.6606	2.33	1.719
	9°31’38.5”N 76°26’34.5”E	0.51	0.484	1.31	1.1157	1.35	1.372
	9°31’41.2”N 76°28’43.2”E	0.77	0.534	0.98	0.8167	1.42	1.713
Average Trend		0.69	0.529	0.99	0.86	1.90	1.68
Palakkad- Climate resilient	10°38’04.1”N 76°32’56.3”E	0.49	0.611	1.91	2.3488	2.86	3.560
	10°38’04.8”N 76°33’05.5”E	0.42	0.458	0.90	1.2430	3.35	3.538
	10°37’43.3”N 76°33’07.3”E	0.69	0.503	0.83	1.3908	1.82	3.517
	10°37’47.5”N 76°32’52.9”E	0.75	0.499	0.90	1.1531	1.64	3.583
Average Trend		0.59	0.518	1.14	1.5339	2.42	3.549
Palakkad - Conventional	10°38’20.7”N 76°32’33.4”E	0.29	0.448	0.63	1.5921	0.76	3.182
	10°38’24.9”N 76°32’46.1”E	0.42	0.544	0.79	2.2618	0.93	3.342
	10°38’11.0”N 76°32’58.2”E	0.63	0.598	0.98	0.7119	1.13	3.543
	10°38’09.0”N 76°32’34.2”E	0.60	0.565	0.96	1.9613	1.11	3.416
Average Trend		0.48	0.54	0.84	1.63	0.98	3.37

Thrissur- Climate resilient	10°13′31.1″N 76°18′18.0″E	0.32	0.368	0.74	0.717	2.20	2.030
	10°13′31.7″N 76°18′40.6″E	0.29	0.354	0.65	0.544	2.13	1.920
	10°13′43.8″N 76°18′33.3″E	0.47	0.355	0.56	0.721	1.89	1.670
	10°13′45.1″N 76°18′22.5″E	0.57	0.359	0.99	0.595	2.48	2.201
Average Trend		0.41	0.359	0.73	0.644	2.18	1.955
Thrissur- Conventional	10°13′23.4″N 76°18′12.3″E	0.36	0.354	0.49	0.547	1.71	2.067
	10°13′20.7″N 76°18′37.5″E	0.26	0.363	0.39	0.498	1.05	1.927
	10°13′09.9″N 76°18′41.5″E	0.23	0.350	0.35	0.545	2.32	1.966
	10°13′06.5″N 76°18′24.5″E	0.28	0.354	0.41	0.498	2.66	1.341
Average Trend		0.28	0.560	0.56	0.8565	1.31	1.83
Kottayam- Climate resilient	9°38′58.9″N 76°26′03.6″E	0.62	0.6188			2.22	1.566
	9°39′08.3″N 76°26′09.9″E	0.98	0.8211			2.00	1.557
	9°25′20.6″N 76°31′48.0″E	0.45	0.9084			1.67	1.368
	9°25′54.7″N 76°31′50.2″E	0.34	0.9846			1.35	1.426
Average Trend		0.60	0.8332			1.81	1.479
Kottayam- Conventional	9°38′37.1″N 76°25′40.9″E	0.95	0.8729	Nil		1.15	1.549
	9°38′40.7″N 76°25′32.8″E	0.46	0.7511			1.36	1.544
	9°25′54.7″N 76°31′47.3″E	0.55	0.9412			1.01	1.520
	9°25′42.1″N 76°31′48.4″E	0.17	0.5069			1.26	1.481
Average Trend		0.53	0.77			1.19	1.52

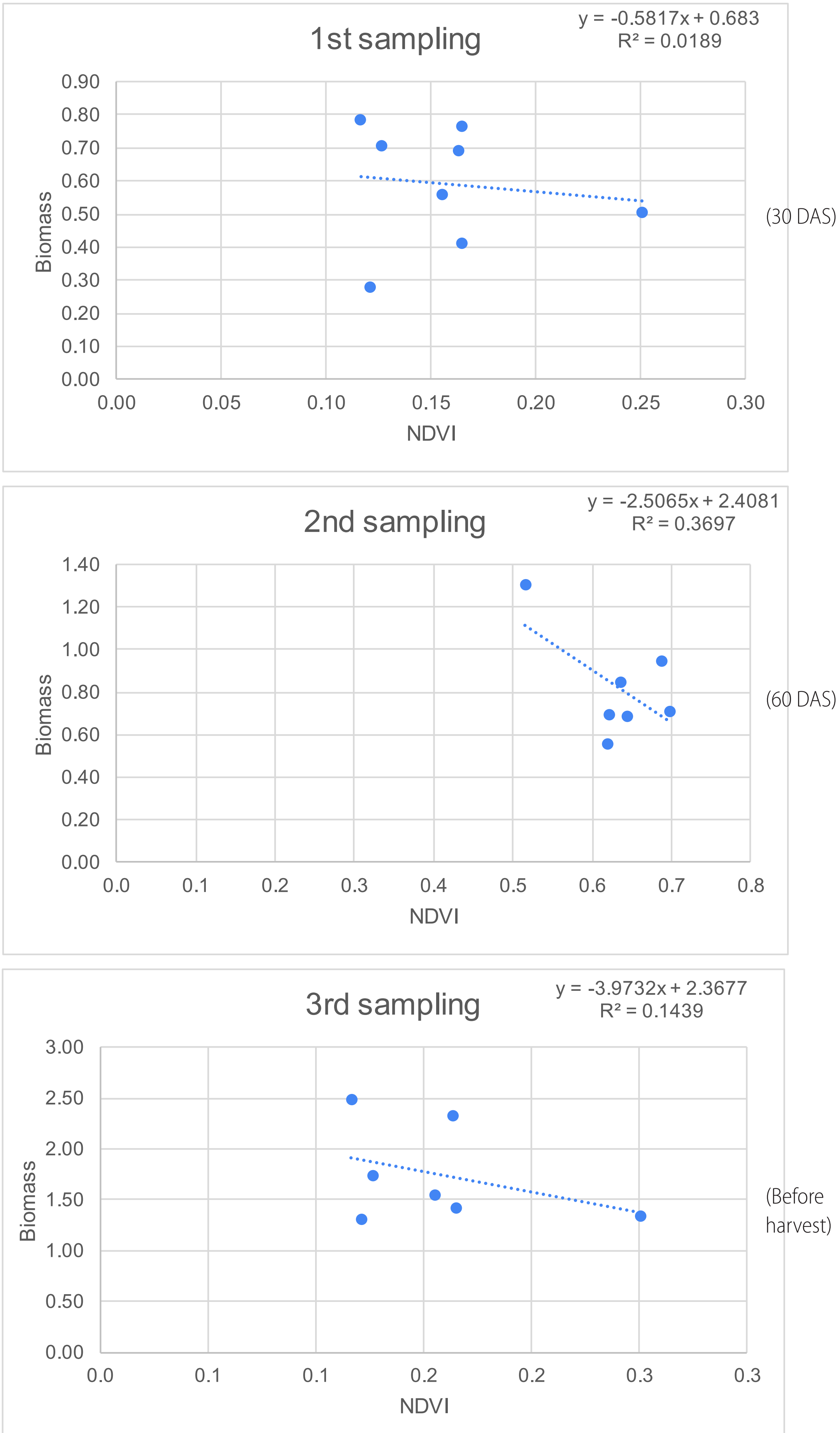
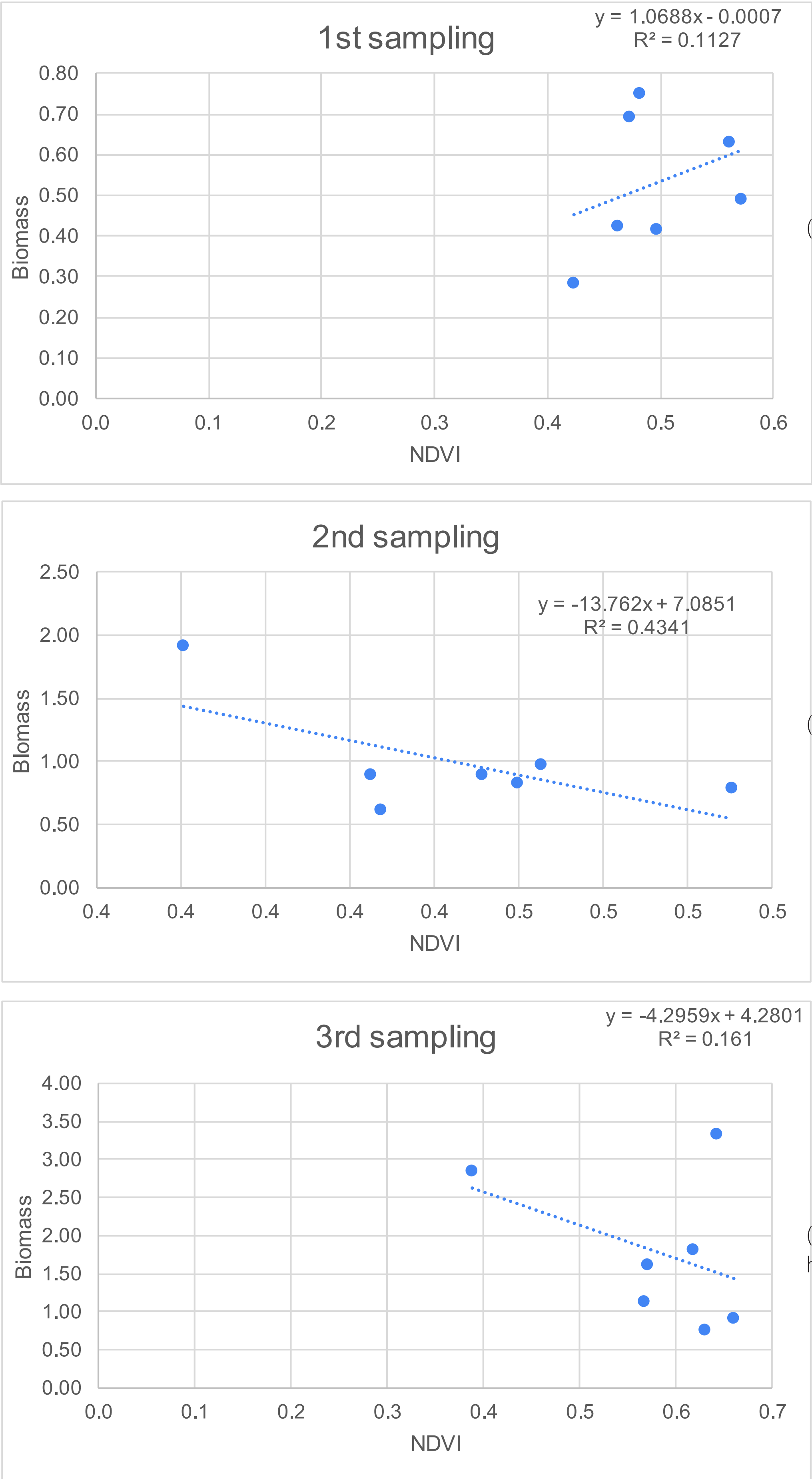


Fig. 5.11. Linear relationship between NDVI and biomass in Kavalam, Alappuzha

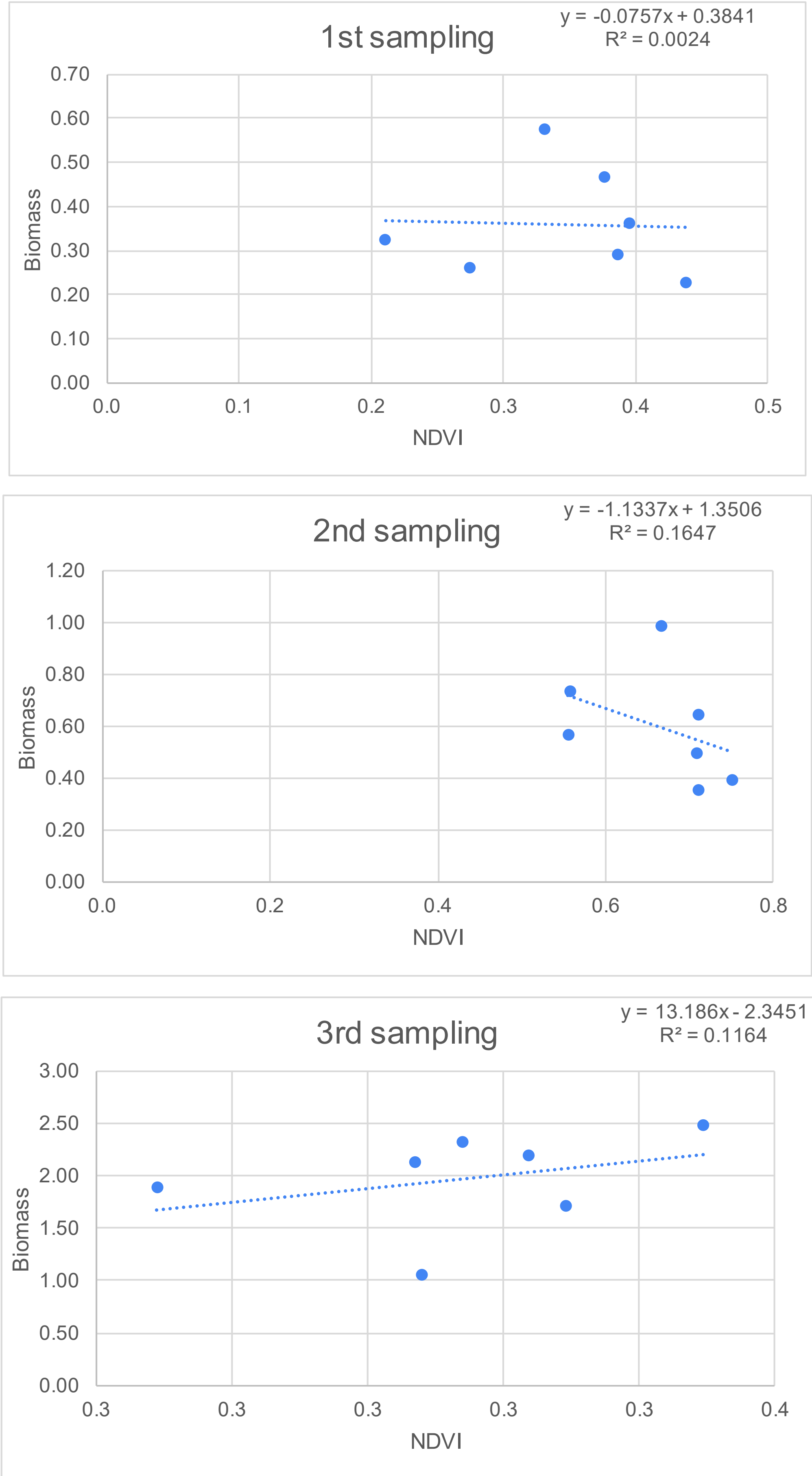


(30 DAS)

(60 DAS)

(Before harvest)

Fig. 5.12. Linear relationship between NDVI and biomass in Alathur, Palakkad

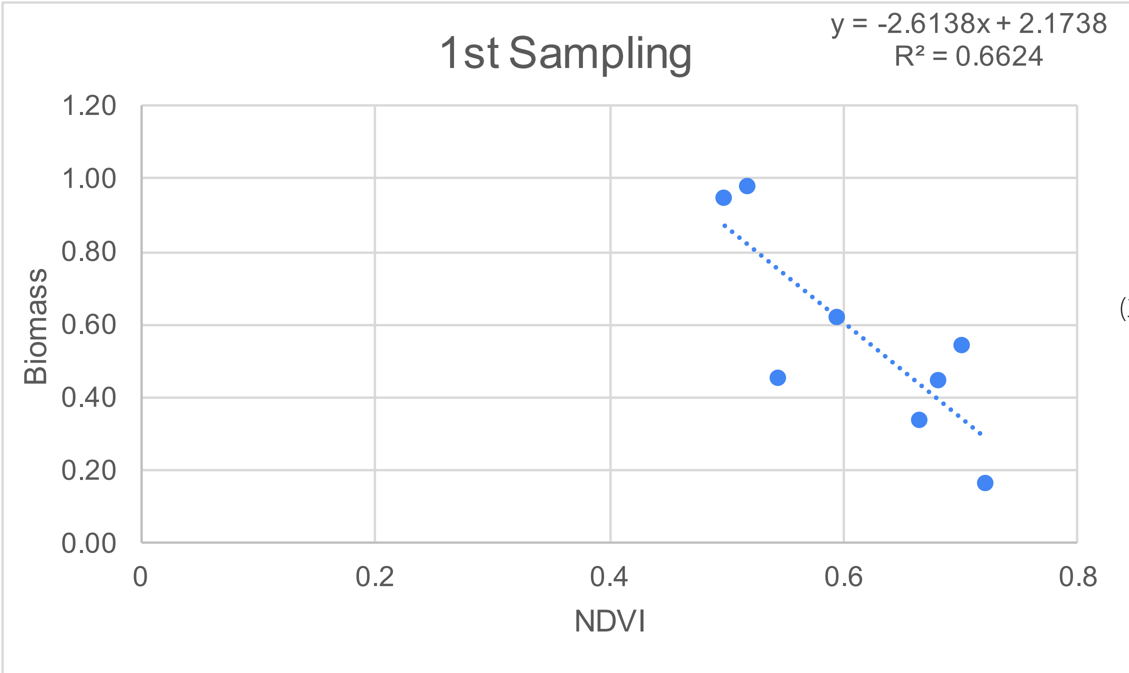


(30 DAS)

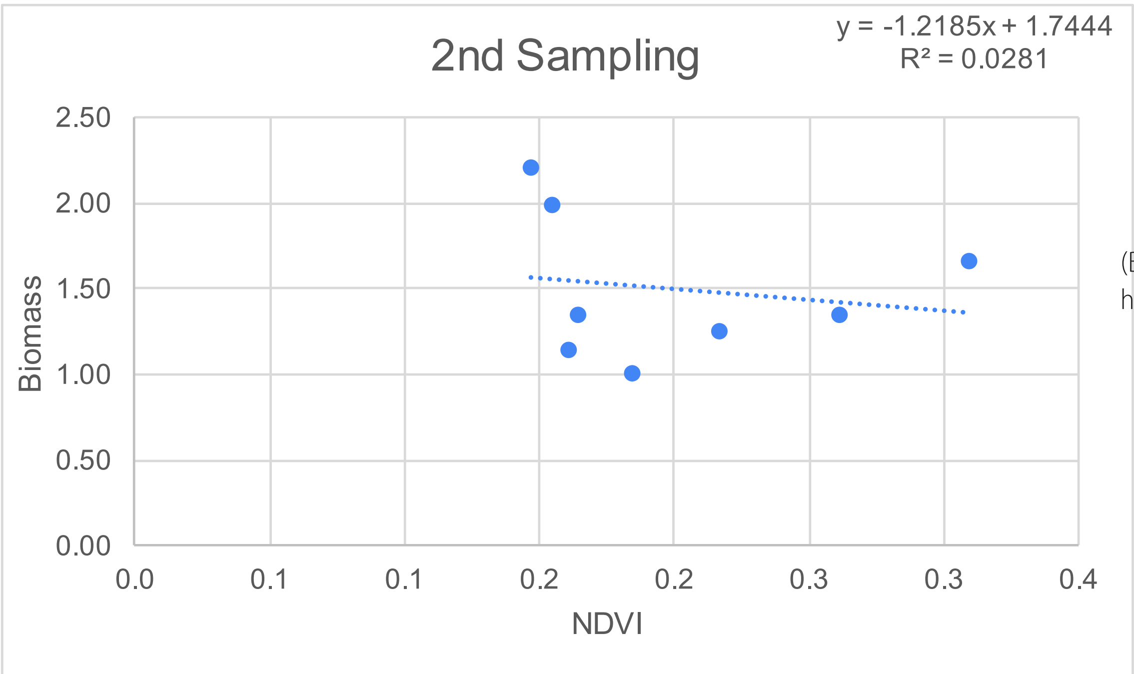
(60 DAS)

(Before harvest)

Fig.5.13. Linear relationship between NDVI and biomass in Annamananada, Thrissur



(30 DAS)



(Before harvest)

Fig.5.14. Linear relationship between NDVI and biomass in Kumarakom & Changanassery, Kottayam

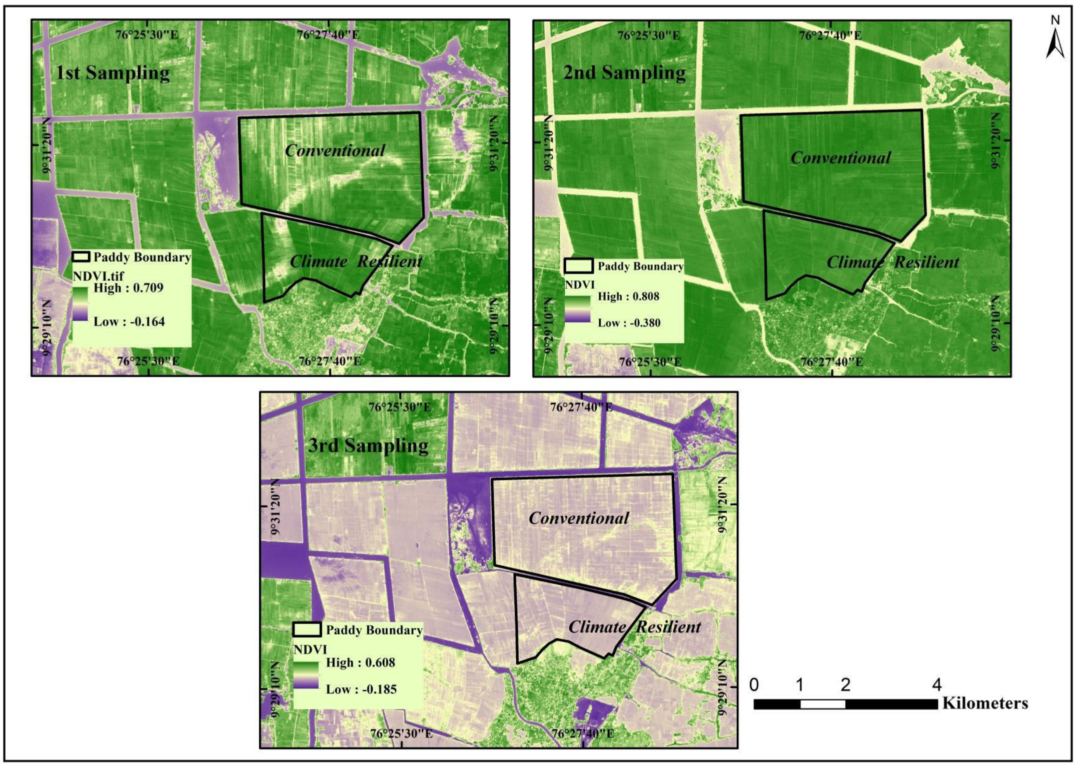


Fig. 5.15. NDVI maps of Kavalam (Alappuzha) at different stages

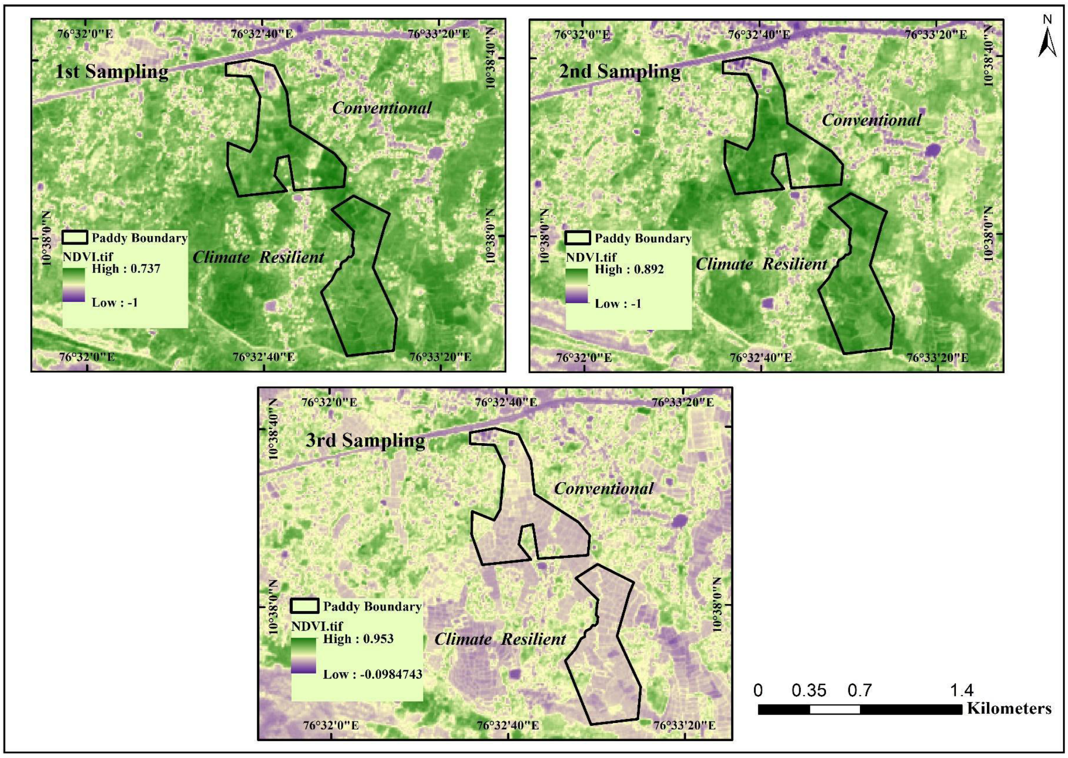


Fig. 5.16. NDVI maps of Alathur (Palakkad) at different stages

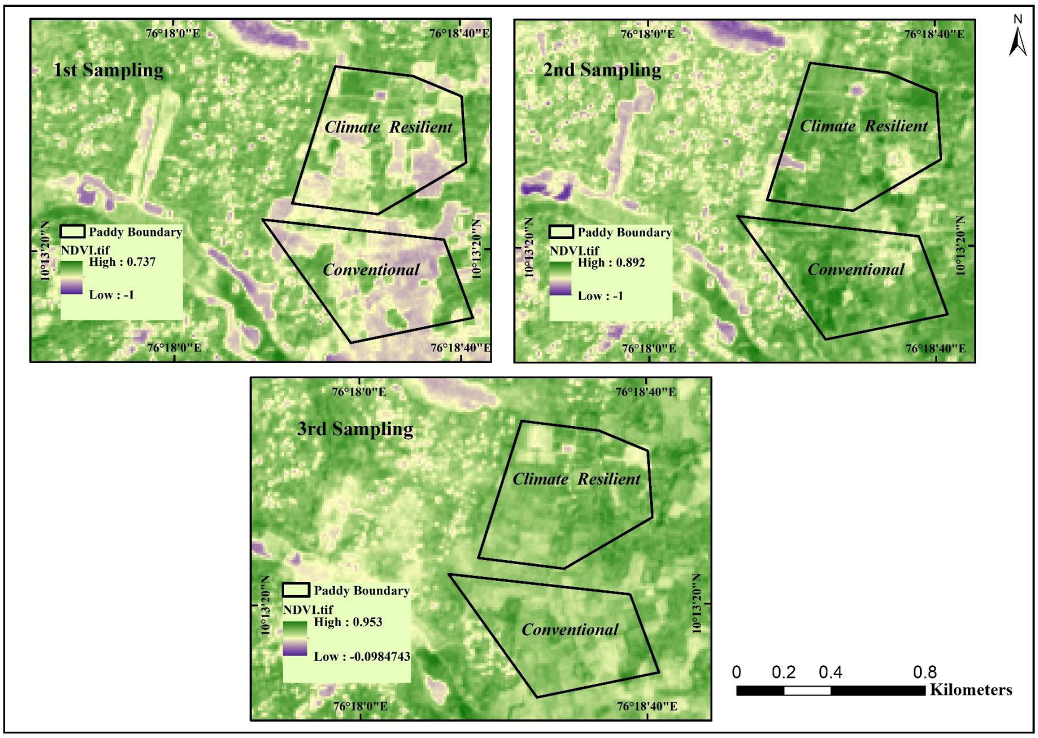


Fig. 5.17. NDVI maps of Annamananada (Thrissur) at different stages

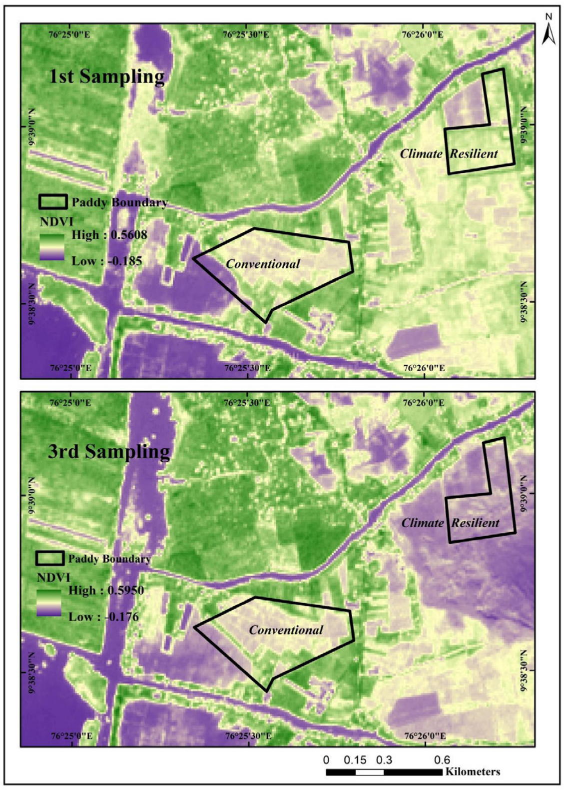


Fig.5.18. NDVI maps of Kumarakom (Kottayam) at different stages

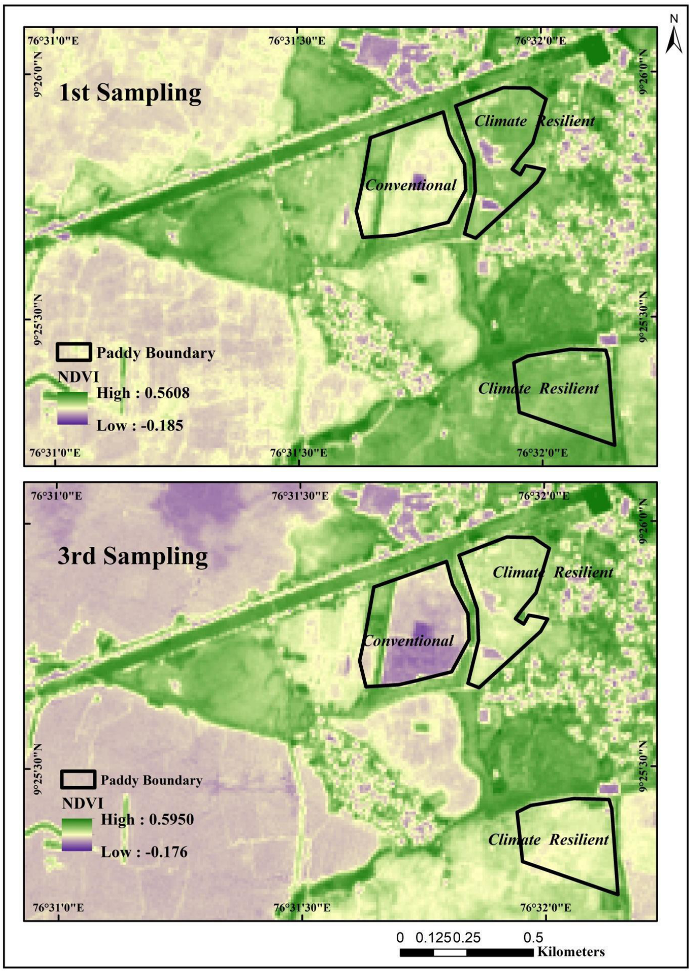


Fig.5.19. NDVI maps of Changanassery (Kottayam) at different stages

Fig. 5.20. Estimate biomass of Kavalam (Alappuzha) sampling region

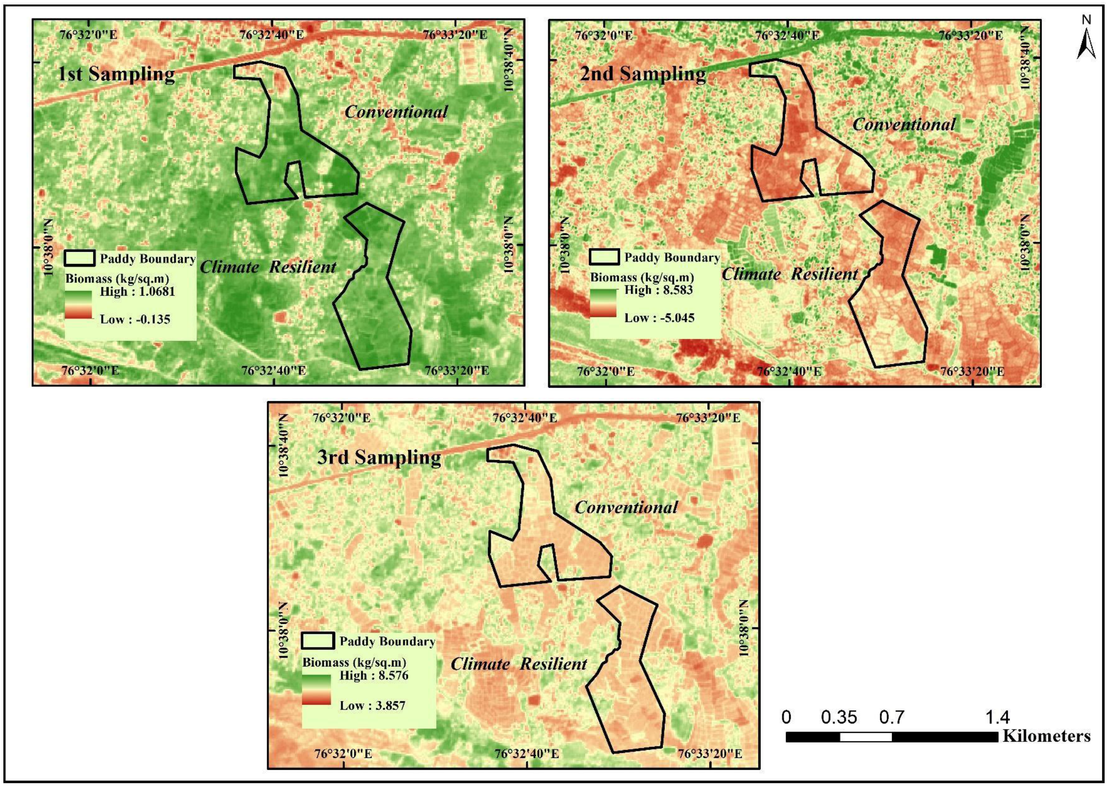


Fig. 5.21. Estimated biomass of Alathur (Palakkad) sampling region

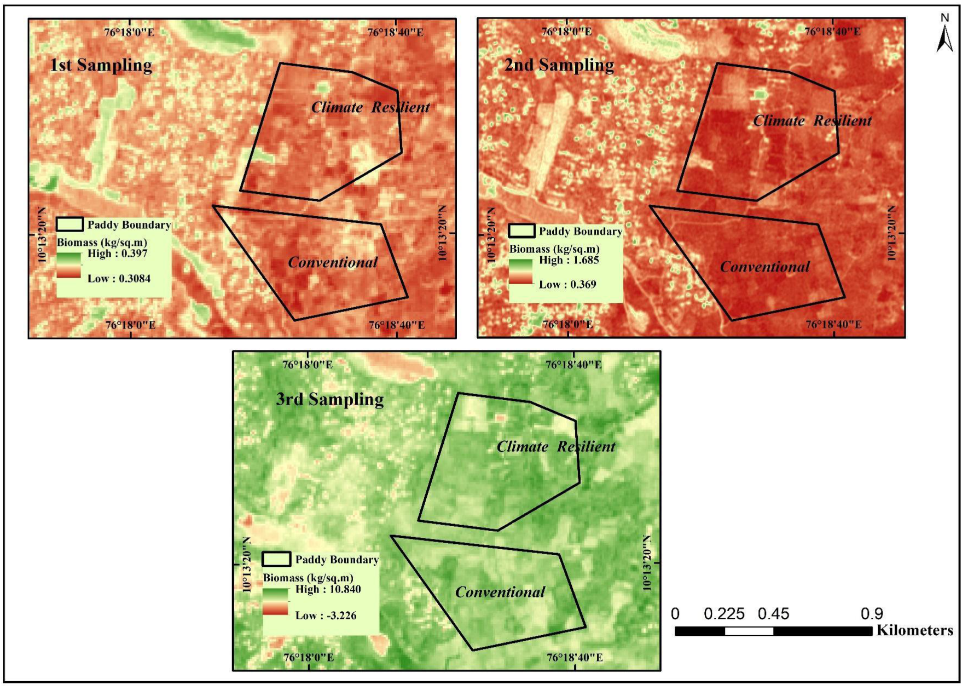


Fig. 5.22. Estimated biomass of Annamananada (Thrissur) sampling region

Fig.5.23. Estimated biomass of Kumarakom (Kottayam) sampling region

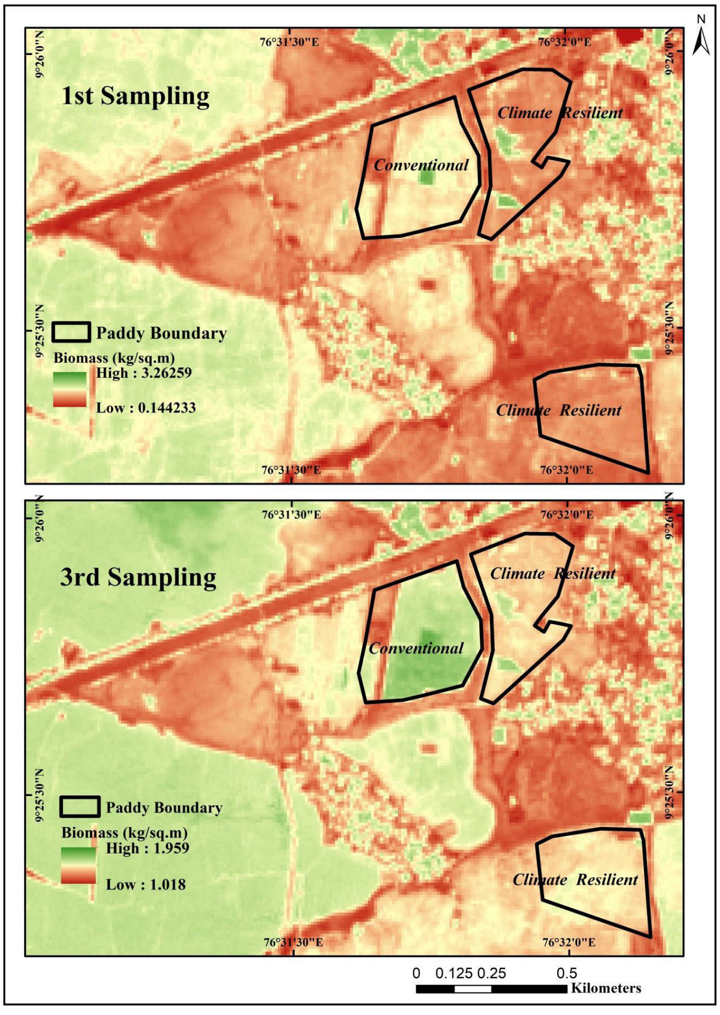


Fig.5.24. Estimated biomass of Changanassery (Kottayam) sampling region

Table 5.7. Trend of biomass estimated through digital image processing (estimated biomass) at various sampling plots

Sl.No	Location	Average Biomass (kg/sq. m)		
		1st sampling	2nd sampling	3rd sampling
1	Kavalam	9.07	21.70	9.91
2	Kumarakom	4.56	0.00	23.92
3	Changanassery	4.55	16.37	50.04
4	Annamananada	20.17	34.20	155.39
5	Alathur	4.58	5.29	36.25

5.3.2.1.1. Results

- The trend of biomass accumulation observed across the different sampling plots was consistent between the manually calculated field biomass values and the estimated biomass values derived from satellite-based digital image processing. Both methods reflected similar seasonal patterns and relative differences across climate-resilient and conventional fields, indicating agreement between ground-based measurements and remote sensing estimates.
- Correlation between NDVI and biomass calculated from field inventory was generated for each sampling plot of different stages. High correlation was observed in Kottayam plot with an r^2 value of 0.66.
- By observing the biomass values of different stages high biomass values were found in the 3rd sampling season in all sampling plots. Compared to climate resilient sampling plots high biomass was found in conventional plots (Table 5.7). This pattern aligns with the findings of Mallikarjun et al. (2024), who reported that conventional farming systems demonstrated elevated vegetative growth and yield attributes relative to organic and natural systems, primarily due to the intensive application of synthetic fertilizers. However, such accelerated growth under conventional management is often physiologically imbalanced and ecologically unsustainable, as it stems from exogenous nutrient enrichment rather than intrinsic soil fertility. This form of biomass proliferation may reflect stress-induced or non-resilient productivity, potentially compromising long-term soil health, nutrient cycling, and agroecosystem stability.
- One would normally expect biomass to increase with NDVI (more green vegetation → higher biomass), yet in some sampling plots higher biomass have lower NDVI due to;
  * Background soil or water reflections (early canopies are sparse, so higher NDVI may actually pick up wet or bare-soil signals that don't correspond to AGB).
  * Sensor saturation or calibration biases when the canopy is still thin.
- Average biomass (predicted) of adjacent paddy fields shows that Alathur paddy fields have high biomass value. In all sampling plots higher biomass was found in 3rd season followed by 2nd and 1st season (Table 5.6).
- Higher biomass was found in climate-resilient fields than conventional in Alathur, Palakkad. One major factor contributing to this could be the use of mechanical transplanters in the climate-resilient plots, in contrast to predominantly manual transplanting in the conventional fields of Palakkad. Mechanized transplanting ensures uniform plant spacing, consistent planting depth, and reduced transplanting shock—all of which create favorable conditions for early root establishment and vigorous vegetative growth. These factors collectively contribute to higher aboveground biomass accumulation. Supporting this, Vijay et al. (2023) reported that rice transplanted using a mechanical transplanter exhibited superior growth parameters, including a higher number of productive tillers and longer panicles, leading to increased biomass and grain yield. The reduced drudgery and timely transplanting facilitated by machinery also play a role in optimizing plant development. Therefore, the use of mechanized transplanting under the climate-resilient protocol in Alathur likely contributed to the enhanced biomass observed in those plots compared to conventional manually transplanted fields.

- The differences between satellite-derived and field-estimated data are primarily due to the limited sample size, which affects statistical reliability, and temporal mismatches between the dates of field biomass collection and satellite image acquisition.

5.3.2.2 Above-Ground Biomass Carbon Content Dynamics During the Cropping Season (Puncha/Second crop)

Above-ground biomass carbon content generally increased consistently from 30 DAS towards Before Harvest across all districts and farming systems, reflecting typical crop growth and atmospheric carbon assimilation (Table 5.8, Figure 5.25). In Palakkad, the Climate Resilient Field recorded a significantly higher AGBC at harvest (Table 5.9), reaching 12.08 t C/ha compared to 4.91 t C/ha in the Conventional Field. In Thrissur, a significant difference was observed at 60 DAS (Table 5.9), where the CRF outperformed the CF in AGBC accumulation. However, by harvest, the difference between systems was no longer statistically significant. In Kottayam, AGBC was also higher in the CRF at harvest, with a near-significant difference (Table 5.9). In Alappuzha, no significant differences in AGBC were observed at any stage, despite the Conventional Field recording consistently higher biomass, likely due to excessive fertilizer use.

Table 5.8. AGBC content (t C/ha) at different stages of the cropping cycle in various districts and farming systems

District	Farming System	30 DAS	60 DAS	Before Harvest
Alappuzha	CRF	2.46	3.51	7.54
	CF	3.45	4.94	9.5
Palakkad	CRF	2.95	5.69	12.08
	CF	2.42	4.2	4.91
Thrissur	CRF	2.07	3.67	10.88
	CF	1.41	2.05	9.66
Kottayam	CRF	2.99	N/A	9.05
	CF	2.66	N/A	5.97

Note: In Kottayam, due to the short-duration (90 days) variety cultivated, only two samplings were conducted for AGB carbon content: 30 DAS and Before Harvest. The '60 DAS' column is marked 'N/A' (Not Applicable) for this district.

Table 5.9. Independent samples t-test results comparing AGBC between Climate-Resilient and Conventional paddy fields across districts

District	Stage	t-value	p-value (two-tailed)	Significance
Palakkad	30 DAS	1.013	0.347	Not Significant
	60 DAS	1.142	0.337	Not Significant
	Before Harvest	3.398	0.043	Significant
Kottayam	30 DAS	0.344	0.742	Not Significant
	Before Harvest	3.063	0.055	Marginal ($p \sim 0.05$)
Thrissur	30 DAS	1.726	0.159	Not Significant
	60 DAS	3.573	0.036	Significant
	Before Harvest	0.657	0.553	Not Significant
Alappuzha	30 DAS	-1.718	0.144	Not Significant
	60 DAS	-2.149	0.119	Not Significant
	Before Harvest	-1.249	0.296	Not Significant

Level of significance: 5% ($p < 0.05$)

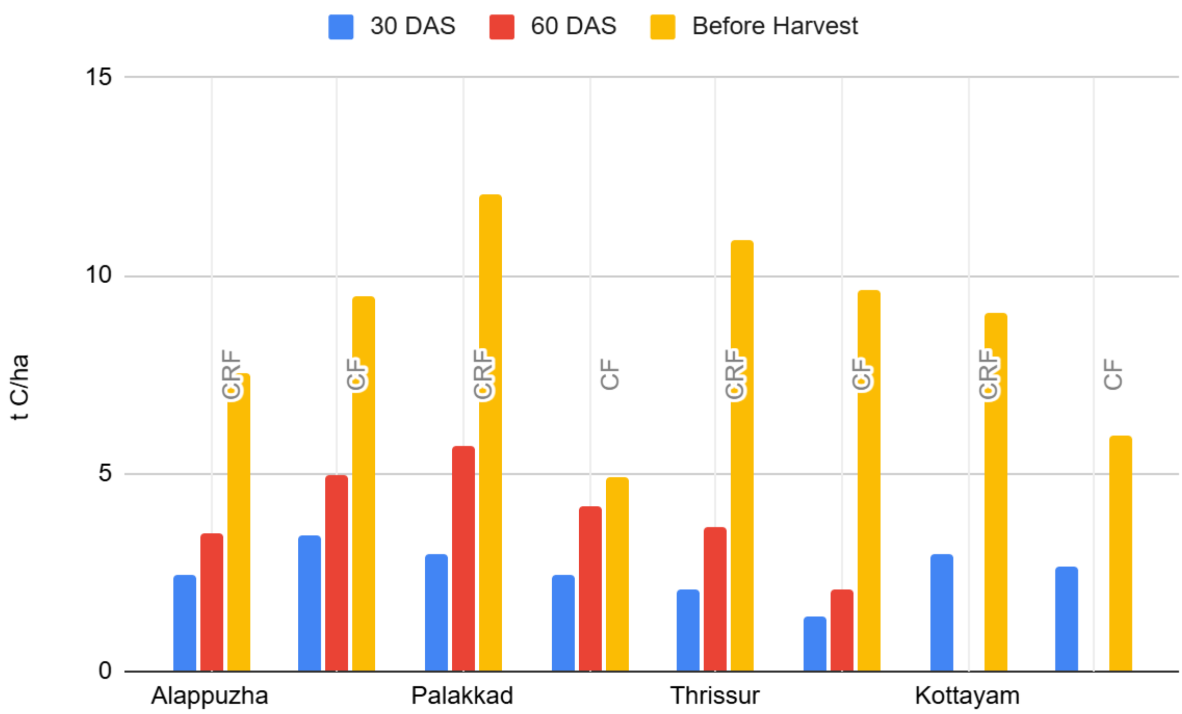


Figure 5.25. Temporal accumulation of AGBC content (t C/ha) across different districts and farming systems

Above-ground biomass carbon content generally increased consistently from 30 DAS towards Before Harvest across all districts and farming systems, reflecting typical crop growth and atmospheric carbon assimilation (Table 5.7, Figure 5.25). While the Climate Resilient Field consistently demonstrated higher AGB carbon accumulation by harvest in Palakkad, Thrissur, and Kottayam, the Conventional Field in Alappuzha maintained higher AGB carbon levels throughout its growth stages. This difference in Alappuzha is likely due to the high inorganic input usage in the Conventional Field, which led to excessive biomass growth. This trend is further confirmed by satellite-driven biomass estimation, which supports the observed patterns of AGB carbon accumulation across both field types.

5.3.2.3 Above-Ground Biomass Carbon Change

To assess the net carbon accumulated in above-ground biomass during the growth phase, the Net Above-Ground Biomass Carbon Change was calculated as the difference between the AGB carbon content at Before Harvest and at 30 DAS. This metric provides an overall measure of carbon assimilation by the crop over the majority of its life cycle. Table 5.10 summarizes these calculated Changes for each district and farming system.

Table 5.10. AGBC change (t C/ha) (before harvest vs. 30 DAS) in different districts and farming systems

	Climate resilient	Conventional
Alappuzha	5.08	6.05
Palakkad	9.13	2.48
Thrissur	8.80	8.25
Kottayam	6.05	3.31

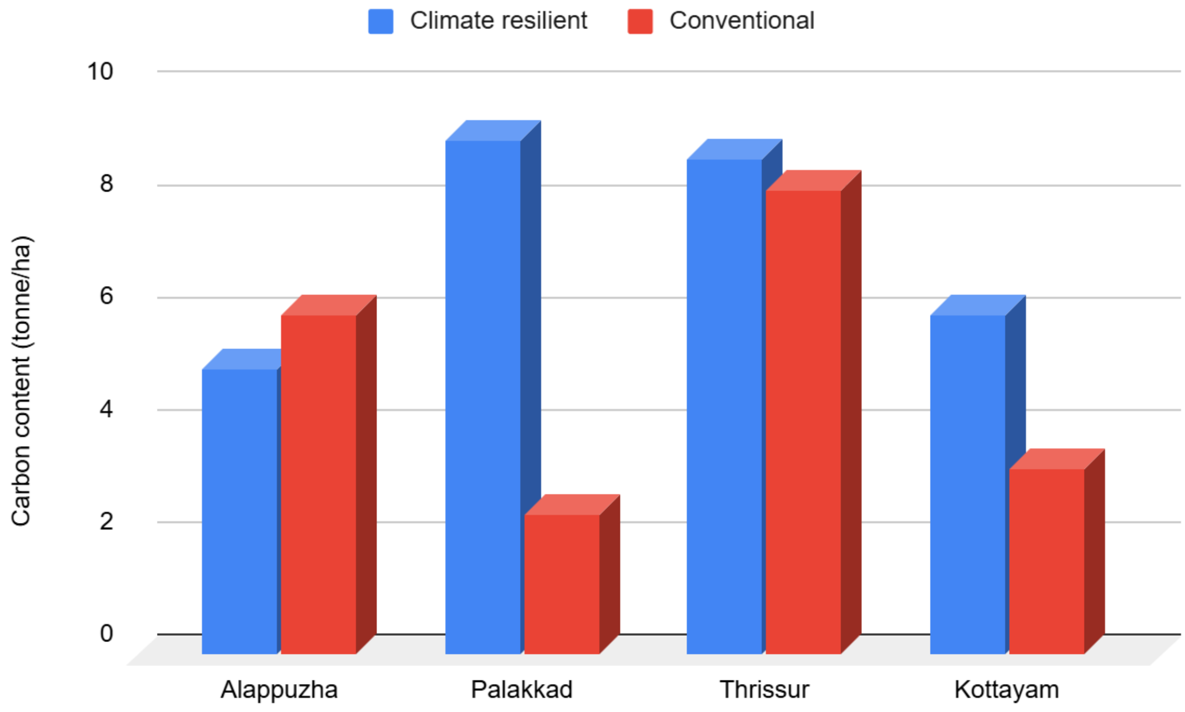


Figure 5.26. AGBC change (t C/ha) across different districts and farming systems

The analysis of AGB Carbon Change (Table 5.10, Figure 5.26) reveals varied patterns across the districts. The Climate Resilient Field demonstrated notably higher AGB carbon change in Palakkad (9.13 t C/ha) and Kottayam (6.05 t C/ha) compared to their Conventional Field counterparts (2.48 t C/ha and 3.31 t C/ha, respectively). In Thrissur, both systems showed comparable changes, with CRF at 8.80 t C/ha and CF at 8.25 t C/ha. Conversely, in Alappuzha, the Conventional Field achieved a higher Net AGB Carbon Change of 6.05 t C/ha compared to the Climate Resilient Field's 5.08 t C/ha, which is likely due to the indiscriminate inorganic input application in Conventional Fields leading to excessive biomass growth.

5.4. DISCUSSION

The temporal dynamics of Soil Organic Carbon and above-ground biomass carbon in paddy ecosystems are intricately linked to crop growth stages and the management practices employed. Typically, SOC levels increase during the early vegetative phase due to enhanced root exudation, microbial activity, and soil disturbance following land preparation and nutrient application. As the crop progresses into mid-growth stages (60–90 DAS/DAT), carbon inputs continue through active root systems. However, approaching harvest, SOC levels often stabilize or decline due to reduced root activity and accelerated microbial decomposition under warm, moist conditions (Lal, 2004; Six et al.,2006).

Above-ground biomass carbon follows a complementary but distinct pattern. Initial biomass accumulation is modest as plants prioritize root establishment. From mid-growth onwards, rapid dry matter production occurs, driven by tillering, stem elongation, and canopy expansion. Peak AGBC is typically reached at harvest when both vegetative and reproductive structures contribute to total biomass. Management practices such as the System of Rice Intensification (SRI), which involves planting young seedlings at wider spacing with intermittent irrigation and active soil aeration to enhance root and tiller development, drum seeding, and alternate wetting and drying (AWD) irrigation—a water-saving method where fields are periodically allowed to dry between irrigations to promote deeper root growth—can amplify this process by promoting stronger root systems, improving nutrient uptake, and enhancing overall plant vigor (Venkataravana Nayaka et al. 2020).

5.4.1 District-Specific Carbon Dynamics Analysis

5.4.1.1 Palakkad

In Palakkad, the Climate Resilient Field demonstrated markedly superior performance in both SOC stock and AGBC accumulation (Table 5.3, Figure 5.9, Table 5.8, Figure 5.25). The final SOC stock in the CRF reached 58.58 t C/ha (Table 5.5, Figure 5.10), significantly surpassing the Conventional Field. This outcome is statistically supported by the significant difference recorded at 30 DAS, confirming the early-stage carbon sequestration benefits of the climate-resilient protocol in this district (Table 5.4).

This robust soil carbon retention indicates effective carbon input and stabilization under the CRF management system. Complementing this, AGBC in the CRF reached 12.08 t C/ha by harvest (Table 5.10, Figure 5.26), significantly higher than the CF (Table 5.9). This outcome reflects increased primary productivity and greater biomass return potential to the soil.

A major factor contributing to this outcome was the Integrated Nutrient Management (INM) strategy, which combined recommended doses of chemical fertilizers with organic amendments such as compost and neem cake, alongside essential micronutrients. Padbhushan et al. (2021) demonstrated that INM can improve crop yields by up to 4.9%, while also enhancing SOC and microbial biomass carbon—key indicators of healthy, productive soils.

Furthermore, the climate resilient protocol included mixing urea with neem cake at a 5:1 ratio and implementing stage-specific nitrogen fertilizer management using the Leaf Color Chart (LCC). The neem cake served as a natural nitrification inhibitor, extending nitrogen availability and minimizing losses through leaching or volatilization. LCC-based nitrogen application reduced overuse, improved Nitrogen Use Efficiency (NUE), and ensured steady nutrient supply during critical growth stages. These interventions supported vigorous tillering, robust vegetative growth, and higher AGBC accumulation. This aligns with the findings of Surekha et al. (2021), who reported that integrating nitrification inhibitors with precision nitrogen management enhances nitrogen retention, plant biomass, and reduces greenhouse gas emissions in rice systems.

Additionally, the climate-resilient protocol emphasized optimized use of chemical inputs and incorporated biocontrol agents for pest management, reducing dependency on synthetic pesticides. This eco-friendly approach supports beneficial soil microbial populations, which play a key role in carbon stabilization. These results are consistent with Gattinger et al. (2012), who reported that systems with reduced chemical inputs accumulate higher soil carbon due to enhanced organic matter cycling and biological activity.

5.4.1.2 Alappuzha

Alappuzha exhibited a distinct carbon dynamic, characterized by high initial SOC stocks in both farming systems (Table 5.3) and substantial early-season SOC increases (Table 5.5). In the CRF, the SOC stock reached 55.35 t C/ha by harvest, while the CF also showed a considerable final SOC stock of 40.05 t C/ha.

The elevated SOC values, particularly in the CRF, align with observations from Gladis et al. (2020), who reported organic carbon content up to 9.38% in the acid sulfate soils of Kuttanad, alongside significant soil carbon stocks (115.96 Mg ha^{-1}) and passive carbon pools. These intrinsic soil characteristics, combined with climate-resilient interventions such as drum sowing for uniform spacing, soil test-based nutrient management, and micronutrient application, contributed to enhanced root biomass, microbial activity, and higher soil organic carbon retention in the CRF plots. Kumar et al. (2021) highlighted that optimized crop geometry and precise nutrient management significantly improve tillering, dry matter accumulation, and root proliferation—all factors that increase organic inputs to the soil.

In contrast, the Conventional Field recorded higher AGBC throughout the season, culminating in a net AGBC change of 6.05 t C/ha (Table 5.10). This outcome reflects the intensive application of chemical fertilizers in conventional farming, which rapidly increases nutrient availability and promotes vigorous vegetative growth. This pattern is consistent with Mallikarjun et al. (2024), who reported that conventional systems often display higher short-term plant growth and yield metrics due to excessive inorganic fertilizer use. However, Zhou et al. (2021) caution that while such practices may enhance immediate biomass accumulation, they can undermine long-term soil carbon stability and increase greenhouse gas emissions, presenting a trade-off between productivity and sustainability.

5.4.1.3 Kottayam

In Kottayam, the comparison between CRF and CF revealed critical differences in both SOC retention and AGBC production. Although the CF started with higher initial SOC, it experienced a net SOC loss of 16.11 t C/ha over the cropping season (Table 5.5, Figure 5.10), indicating carbon mineralization and soil degradation. In contrast, the CRF achieved a final SOC stock increase of 27.75 t C/ha, demonstrating successful carbon retention under climate-resilient management. The SOC difference in Kottayam was statistically significant at 30 DAS and before harvest (Table 5.4). This indicates that climate-resilient interventions not only prevented carbon depletion but actively improved carbon stocks, even under salinity stress conditions. Above-ground biomass carbon was also higher in the CRF at harvest

(9.05 t C/ha), (Table 5.8, Figure 5.25) with a marginally significant difference (Table 5.9) indicating a positive trend despite environmental constraints like salinity stress.

It is important to note that overall carbon values in Kottayam were lower than in other districts, largely due to saltwater intrusion that affected the experimental plots during the cropping season. Salinity stress is well-documented to suppress plant biomass productivity and reduce microbial activity, leading to diminished organic inputs and impaired soil carbon stabilization (Setia et al. 2011).

Despite these environmental constraints, the adoption of climate-resilient practices—such as drum sowing for uniform plant establishment, INM, reduced chemical usage, and LCC-guided nitrogen management—helped mitigate carbon depletion. These interventions supported better plant health, improved root development, and maintained both SOC and AGBC under salinity-stressed conditions.

5.4.1.4 Thrissur

In Thrissur, both CRF and CF recorded positive SOC changes over the cropping period (Table 5.3). The CF showed a higher early-season SOC increase (22.95 t C/ha) compared to the CRF (17.82 t C/ha) (Figure 5.10). This unexpected trend is primarily attributed to unseasonal rainfall immediately after sowing in the CRF, resulting in localized flooding and partial seedling damage. In contrast, the CF was sown later and avoided this initial stress event.

Early-stage flooding disrupts plant establishment, reduces root exudation, and limits the incorporation of fresh organic matter into the soil. Bhattacharyya et al. (2020) and Wang et al. (2018) reported that abnormal hydrological events in paddy systems can suppress carbon sequestration by damaging seedlings and altering microbial carbon pathways.

Despite this initial setback, the CRF exhibited a strong recovery in terms of biomass productivity. At 60 DAS, the CRF significantly outperformed the CF in Above-Ground Biomass Carbon accumulation (Table 5.9), reflecting rapid vegetative recovery following the early stress event. By harvest, AGBC in the CRF reached 10.88 t C/ha, compared to 9.66 t C/ha in the CF (Table 5.10). The net AGBC change was also higher in the CRF (Table 5.10), indicating that once environmental conditions normalized, the climate-resilient management facilitated compensatory growth and improved biomass returns.

5.5. CONCLUSION

The district-wise analysis demonstrates that climate-resilient paddy management consistently enhances carbon dynamics in Kerala's paddy ecosystems. Despite site-specific environmental stresses such as salinity intrusion in Kottayam and untimely rainfall in Thrissur, the integrated protocol—comprising precision nutrient management, optimized chemical inputs, improved sowing techniques and eco-friendly pest control—effectively supported both biomass productivity and soil carbon retention. In contrast, conventional farming approaches, while occasionally producing higher short-term biomass changes due to intensive fertilizer use, risk long-term soil degradation and carbon loss.

The suite of climate-resilient interventions evaluated in this study not only promoted robust plant growth and improved soil health but also significantly contributed to carbon sequestration—addressing both productivity and sustainability goals. These findings highlight the potential for scalable, farmer-friendly solutions that are adaptable to evolving climatic challenges.

In conclusion, the climate-resilient paddy farming protocol offers a viable pathway for enhancing carbon sequestration, mitigating climate change, and fostering resilience in rice-based agroecosystems. Its widespread adoption, tailored to local agroecological conditions, can serve as a cornerstone for sustainable agricultural development and environmental stewardship in Kerala and beyond.

5.6. SUMMARY

- Climate-resilient paddy farming practices significantly enhanced both SOC and AGBC compared to conventional rice cultivation across the four study districts in Kerala.
- In Palakkad, climate-resilient fields achieved the highest SOC change of 58.58 t C/ha and AGBC of 12.08 t C/ha. SOC was significantly higher at 30 DAS, and AGBC was significantly greater at harvest, reflecting better adoption of climate-resilient practices.
- In Kottayam, climate-resilient plots prevented carbon loss under salinity stress, recording a SOC change of 27.75 t C/ha, while conventional plots experienced a net SOC loss of 16.11 t C/

ha. AGBC in climate-resilient fields was 9.05 t C/ha, substantially higher than the 5.97 t C/ha observed in conventional plots.

- In Thrissur, despite early-season flooding in the climate-resilient plots, compensatory growth resulted in significantly higher AGBC at 60 DAS. By harvest, AGBC in the climate-resilient fields reached 10.88 t C/ha, compared to 9.66 t C/ha in the conventional fields.
- In Alappuzha, both systems maintained high SOC stocks due to naturally carbon-rich soils. The CRF recorded 55.35 t C/ha, while the CF reached 40.05 t C/ha by harvest. However, conventional fields prioritized AGBC accumulation through intensive chemical use, whereas climate-resilient fields ensured better long-term soil carbon stability.
- Remote sensing analysis using LISS IV satellite data confirmed the field-based biomass estimates. Linear regression between NDVI and field AGBC validated the consistency of the biomass data across locations.
- Overall, climate-resilient rice farming demonstrated superior carbon sequestration and biomass productivity, providing a scalable and sustainable solution for climate change mitigation and enhancing resilience in Kerala's rice-based agroecosystems.|

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CHAPTER 6
Executive Summary of the Project

6.1. EXECUTIVE SUMMARY

- Climate Change as the Major Threat: Climate change-related issues are undeniably the paramount challenge confronting paddy farmers throughout Kerala. This critical finding is robustly supported by the study, with 48% of surveyed farmers explicitly corroborating these severe impacts.
- Climate-Resilient Protocol Validated: A meticulously structured protocol, integrating successful farmer practices, improved agronomic interventions, and scientific validation, has been effectively implemented. The protocol demonstrated strong farmer adoption, exceeding 50%, and proved feasible across Kerala's diverse agro-ecological zones, indicating its broad applicability and potential for scaling.
- Improved Agronomic & Economic Performance: Fields implemented the climate-resilient protocol significantly outperformed conventional rice farming fields. This superior performance was evident in higher yields, enhanced cost-efficiency, improved input safety, weather event resilience and greater technology adoption. These benefits were particularly pronounced in regions characterized by strong farmer cooperation and robust institutional support.
- Adoption Challenges Identified: Despite the evident benefits, the project identified several critical barriers to wider adoption. These include high input costs, inadequate access to essential inputs and machinery, constraints related to shared irrigation systems, a prevailing lack of trust in agricultural insurance schemes, and inherent difficulties in implementing innovative practices within collective farming settings.
- Carbon Sequestration Enhanced: The implementation of the climate-resilient protocol demonstrated tangible environmental benefits. NDVI linked biomass data, coupled with direct field estimations, confirmed a notable increase in both above-ground biomass and soil organic carbon in protocol-implemented fields. This outcome underscores the protocol's significant role in climate change mitigation through enhanced carbon sequestration.
- Post-Harvest Cost Analysis: An in-depth analysis of post-harvest costs revealed varied regional realities. Thrissur district experienced low costs due to streamlined logistics, while Alappuzha's high costs stemmed from labor-intensive handling and waterbody-based transport through canals and lakes. In Palakkad, drying was the primary cost driver. Notably, low post-harvest costs in Kottayam masked underlying issues such as poor yield and significant deductions due to high moisture content, leading to overall losses for farmers.
- Scalability and Effectiveness: The project conclusively showcased the significant scalability and effectiveness of climate-resilient rice farming protocol. Implementing these practices markedly boosts agricultural productivity, reduces environmental risks, and substantially aids climate change mitigation through enhanced carbon sequestration and sustainable methods.

CHAPTER 7
Recommendations for Future Action

7.1. SUGGESTIONS

Based on the findings of this study, several key areas for improvement have been identified. These suggestions aim to address the operational challenges and systemic constraints observed during the project implementation. The following suggestions are proposed to enhance the effectiveness and sustainability of future interventions.

7.1.1. Strengthen Input Delivery Systems for Inclusive Farmer Benefits

A more comprehensive support system is needed to ensure that farmers receive timely and accessible input assistance, including quality seeds, fertilizers, biocontrol agents, and mechanization services. Despite the availability of multiple schemes and initiatives, farmers often do not fully benefit due to procedural hurdles, delayed disbursements, and lack of integration between advisory services and material support. Without a streamlined mechanism to link technical guidance with input accessibility, the adoption of improved agricultural practices remains limited, especially among financially vulnerable farming communities.

7.1.2. Strengthen Post-Harvest and Marketing Linkages

Farmers faced limited bargaining capacity under the government procurement system due to fixed pricing and rigid procedures. Establishing collective marketing mechanisms or branded product strategies could enhance farmer profits and incentivize quality improvements. Developing value addition units and decentralized storage infrastructure would further reduce post-harvest losses and empower farmers to participate in profitable markets rather than distress sales.

7.1.3. Facilitate Youth Participation in Agriculture

The project observed a sharp decline in youth engagement in farming. Introducing targeted interventions—such as agri-entrepreneurship models, skill development programs, and tech-based farm management—could help attract younger generations to agriculture. Creating modern agri-business hubs, digital platforms for farm management, and offering financial support for start-up farming enterprises could make the sector more appealing to rural youth.

7.1.4. Enhance Farmer Participation in Direct Cultivation

Many landowners outsourced farming operations to laborers, leading to knowledge gaps and weaker implementation of sustainable practices. Encouraging landowners to remain actively involved in decision-making and field-level management is essential for the success of climate-resilient protocols. Tailored awareness programs could revitalize farmer involvement and restore experiential learning.

7.1.5. Encourage Risk Mitigation through Improved Insurance Access

Many farmers showed low participation in crop insurance schemes due to procedural complexity and lack of trust in settlement processes. Simplifying claim mechanisms, and ensuring timely disbursement can improve farmer confidence and provide better resilience against climate shocks.

7.1.6. Integrate Climate Advisory Services with Field Operations

While technical guidelines were disseminated, real-time climate advisory services were limited. Developing localized, ICT-based agro-advisory platforms can help farmers make informed decisions regarding sowing dates, pest management, and water use, increasing adaptive capacity to climatic variations.

7.1.7. Encouraging Household Consumption of Own Produce

A major finding is that many farmers are not consuming the rice they cultivate. This is due to multiple factors: concerns over heavy chemical usage, the labor-intensive traditional processing methods (boiling, drying, milling), and a growing preference for other rice varieties available in the market. To address this, farmers should be encouraged to adopt safer, low-chemical cultivation practices, while support for easier post-harvest processing and awareness about the value of local varieties can help revive household-level consumption.

7.1.8. Promote Collective Farming and Institutional Models

A cooperative approach through FPOs can help overcome structural issues like small landholdings, scattered operations, and lack of economies of scale. Forming FPOs allows farmers to access better inputs, mechanization, market support, and bargaining power. Establishing federated networks of FPOs at the regional level can further strengthen value chain management and policy advocacy.

To address these multi-dimensional challenges and build a more resilient farming ecosystem, institutional models like FPOs are essential. In this context, the TIES Farmer Producer Company Ltd. has been established as a long-term solution to support farmers, revive fallow lands, and rebuild rural livelihoods.

7.2. TIES FARMER PRODUCER COMPANY LTD. (TFPC): A COLLECTIVE SOLUTION FOR SUSTAINABLE AGRICULTURE

The TIES Farmer Producer Company Ltd. is a registered Farmer Producer Organization promoted by the Tropical Institute of Ecological Sciences (TIES) with support from NABARD. The initiative was born out of the recognition that Kerala's agriculture faces systemic issues such as fragmented landholdings, labor shortages, climate unpredictability, and declining profitability. As a result, large areas of fertile farmland remain fallow, and food crop cultivation continues to decline.

TFPC aims to reverse this trend by bringing fallow lands back under productive cultivation through an integrated, community-based farming model. The organization offers farmers and landowners an opportunity to lease unused land to the company under transparent agreements, allowing TFPC to undertake organic and climate-resilient farming operations at scale. A minimum of 15 cents of land can be leased for a period of at least three years, ensuring secure, long-term stewardship of agricultural land.

TFPC provides a full-spectrum farming service, including land preparation, irrigation, mechanization, cultivation, harvesting, and post-harvest processing. The cropping system involves the cultivation of paddy, horse gram, vegetables, fruits, and tubers, along with integrated animal husbandry. The focus is on sustainable, chemical-free, and climate-smart practices that improve soil health, biodiversity, and farmer income.

A core goal of TFPC is to build a branded, naturally grown food line, marketed through hypermarkets, malls, and modern retail outlets under the label "From Fallow to Flourish – Naturally Grown, Kerala Proud." This approach shifts farmers from being price-takers in traditional markets to stakeholders in a branded value chain, offering better returns and market recognition.

Beyond farming, TFPC also addresses the pressing issue of youth disengagement from agriculture. By creating opportunities in agri-entrepreneurship, food processing, marketing, and farm management, TFPC fosters new-generation leadership in the agricultural sector. An AI-powered digital system is being introduced to ensure efficient management and transparent monitoring, allowing shareholders to track operations in real time.

7.2.1. Benefits of TFPC:

- For Farmers and Shareholders:
    * Income generation from otherwise unused land
    * Access to modern, scientific, and sustainable farming practices
    * Participation in profit-sharing from branded products
    * Real-time updates and transparent management through digital tools

- For the Community:
    * Supply of safe, naturally grown food
    * Youth employment and green job creation
    * Revitalized rural livelihoods and food security

- For the Environment:
    * Restoration of soil health and biodiversity
    * Reduction in chemical use and carbon footprint
    * Promotion of climate-resilient agricultural landscapes

Farmers with 15 cents or more of land can become shareholders by purchasing equity shares worth Rs. 1000 (minimum 10 shares). Even landowners residing outside Kerala or abroad can participate by leasing land and contributing to local food production and environmental restoration.

7.3. THE WAY FORWARD

By integrating initiatives like TFPC into future climate-resilient agriculture projects, it is possible to address the core structural challenges of Kerala's farming sector. Combining capacity building with material support, collective market access, sustainable branding, and youth involvement will help transform paddy cultivation from a survival practice into a profitable, dignified, and environmentally sound livelihood.

Appendices

Appendix I
Project Brochure

ഈ ഓഗസ്റ്റ് മാസം മുതൽ അടുത്ത ഓഗസ്റ്റ് വരെയാണ്
ഈ പദ്ധതിയുടെ കാലാവധി. കോട്ടയം, ആലപ്പുഴ, പാലക്കാട്, തൃശ്ശൂർ
എന്നീ ജില്ലകളിലെ നെൽകർഷകർ ചെയ്തുപോരുന്ന
കാലാവസ്ഥാ അതിജിവന കൃഷിരീതികൾ ഏകോപിപ്പിച്ച്
അത് അവരുടെ കർഷകസമിതികളിലൂടെത്തന്നെ
മറ്റു കർഷകരിലേക്കെത്തിച്ച്, വരുന്ന പുഞ്ചസീസണിൽ തന്നെ
കർഷകർ ഈ കൃഷിരീതി പ്രയോഗത്തിൽ കൊണ്ടുവരുന്ന രൂപത്തിലാണ്
ഈ പദ്ധതി ആസൂത്രണം ചെയ്തിട്ടുള്ളത്.
കാലാവസ്ഥാ വ്യതിയാനങ്ങളെ അതിജീവിച്ച് നെൽകൃഷി ചെയ്യുന്ന
സമർത്ഥരായ നെൽകർഷകരുടെ വിജയമാതൃകകൾ ഏകോപിപ്പിച്ച്
അനുകരിക്കുന്ന രീതി അവലംബിക്കുക മുഖേന
കർഷകർക്ക് കൂടിയ വിളവ് ലഭിക്കാനും
കൃഷി ചെലവ് കുറയ്ക്കാനും സഹായകമാകും.

ക്ഷയിച്ചുകൊണ്ടിരിക്കുന്ന കേരളത്തിന്റെ നെൽകൃഷി പൈതൃകത്തിന്റെ
പുനരുജ്ജീവനത്തിനായുള്ള
ഈ പദ്ധതിയിലേക്ക് ഹൃദയപൂർവ്വം സ്വാഗതം.

ടൈസ്
ട്രോപ്പിക്കൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് ഇക്കോളജിക്കൽ സയൻസസ്

ഇക്കോളജിക്കൽ റിസർച്ച് കാമ്പസ്
വെള്ളൂർ പി.ഓ. പാമ്പാടി, കോട്ടയം, കേരളം. പിൻ- 686 501
മഹാത്മാഗാന്ധി യൂണിവേഴ്സിറ്റിയുടെ അംഗീകൃത ഗവേഷണകേന്ദ്രം
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TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES

SUPPORTED BY
NATIONAL BANK FOR AGRICULTURE AND RURAL DEVELOPMENT
NABARD

കേരളത്തിലെ നെൽകൃഷി

കേരളത്തിലെ പ്രധാന ഭക്ഷ്യവിളയാണ് നെല്ല്. ഭക്ഷ്യസുരക്ഷ ഉറപ്പാക്കുന്നതിലും
സമ്പത് വ്യവസ്ഥയെ ശക്തിപ്പെടുത്തുന്നതിലും നെൽകൃഷിക്കുള്ള പങ്ക് വളരെ വലുതാണ്.
എന്നാൽ സമീപകാലത്ത് കേരളത്തിന്റെ നെല്ലുത്പാദനത്തിൽ
ആശങ്കാവാഹകമായ കുറവ് ഉണ്ടായിട്ടുണ്ട്.
1980 മുതൽ 2020 വരെ ആറ് ലക്ഷം ഹെക്ടർ നെൽ വയലുകളാണ്
കേരളത്തിൽ നഷ്ടമായിട്ടുള്ളത്.
ആനുപാതികമായി നെല്ലുത്പാദനത്തിൽ 50 ശതമാനം കുറവുമുണ്ടായിട്ടുണ്ട്.
ജലദൗർലഭ്യം, തൊഴിലാളി ക്ഷാമം, മലിനീകരണം, ഉയർന്ന കൃഷി ചെലവ്,
വിപണിയിലെ അനിശ്ചിതത്വങ്ങൾ, കാലാവസ്ഥാ വ്യതിയാനം മുലമുണ്ടാകുന്ന പ്രതിസന്ധികൾ
എന്നിവയാണ് ഇതിന്റെ പ്രധാന കാരണങ്ങൾ.
ഉയർന്ന അന്തരീക്ഷ ഊഷ്മാവ്, കാലം തെറ്റി പെയ്യുന്ന മഴ, പുതിയയിനം കളസസ്യങ്ങൾ,
അധികരിച്ച കീട-രോഗ ആക്രമണം, തീവ്ര പ്രകൃതി ദുരന്തങ്ങൾ
എന്നിങ്ങനെ കാലാവസ്ഥാ മാറ്റം കൊണ്ടുണ്ടാകുന്ന സാരമായ പ്രതിസന്ധികൾ
നെൽകൃഷിയെ കൂടുതൽ ദുർഘടമാക്കുന്ന സാഹചര്യമാണ് കേരളത്തിൽ ഇപ്പോൾ കണ്ടുവരുന്നത്.

കാലാവസ്ഥാ മാറ്റവും നെൽകൃഷിയും

അന്തരീക്ഷഘടനയിൽ മനുഷ്യപ്രവർത്തികൾ മൂലമുണ്ടാകുന്ന
ദീർഘകാലമാറ്റങ്ങളാണ് കാലാവസ്ഥാ വ്യതിയാനം. മഴക്കാലവും വേനൽക്കാലവും
അടുത്തകാലത്തായി താളം തെറ്റുന്നത്, കാലാവസ്ഥാ വ്യതിയാനം എന്ന
ആഗോളപ്രതിഭാസത്തിന്റെ പരിണിതിയാണ്.
ഇത് പാരിസ്ഥിതിക, സാമൂഹിക സാമ്പത്തിക മേഖലകളിൽ
വിനാശം സൃഷ്ടിച്ചുകൊണ്ടിരിക്കുകയാണ്.

കാലാവസ്ഥാ മാറ്റം എങ്ങനെ നെൽകൃഷിയെ പ്രതികൂലമായി ബാധിക്കുന്നു ?

ഇന്ത്യ ഉൾപ്പെടെയുള്ള വിവിധ രാജ്യങ്ങളിൽ നെൽകൃഷിയെ കാലാവസ്ഥാ മാറ്റം
എങ്ങനെ ബാധിക്കുന്നുവെന്ന് ഒട്ടേറെ പഠനങ്ങൾ നടന്നിട്ടുണ്ട്.

1 ഉയർന്ന അന്തരീക്ഷ താപനില നെല്ലിന്റെ ഗുണനിലവാരവും വിളവും കുറയ്ക്കുന്നു
2 കാലാവസ്ഥാ മാറ്റം മൂലമുള്ള അനിയന്ത്രിതമായ മഴ, കാലം തെറ്റിയുള്ള മഴ
എന്നിവ കൃഷി നാശത്തിനും വിളവ് കുറയുന്നതിനും കാരണമാകുന്നു.
3 വരൾച്ച മൂലമുണ്ടാകുന്ന ജലസ്രോതസ്സുകളുടെ ക്ഷയം ജലദൗർലഭ്യത്തിനു കാരണമാകുന്നു.
4 രോഗങ്ങളുടെയും കീടങ്ങളുടെയും വർദ്ധനവും പുതിയ കീടങ്ങളും രോഗങ്ങളും
നെൽകൃഷിയുടെ ഗുണത്തിലും വിളവിലും കുറവുവരുത്തുന്നു.
5 കളസസ്യങ്ങളുടെ വർദ്ധനവ് വിളയെ പ്രതികൂലമായി ബാധിക്കുന്നു.
ചിലവ് അനിയന്ത്രിതമായി വർദ്ധിക്കുന്നു.
6 ക്രമാതീതമായ മണ്ണൊലിപ്പും മണ്ണിലെ ഉപ്പിന്റെ അളവ് കൂടുന്നതും
മണ്ണിന്റെ ഉല്പാദനശേഷി കുറയ്ക്കുന്നു.
7 അധികരിച്ച പ്രകൃതി ദുരന്തങ്ങൾ കൃഷിനാശത്തിനു വഴിയൊരുക്കുന്നു.

പ്രോജക്റ്റ്

കാലാവസ്ഥാ മാറ്റം മൂലമുള്ള വെല്ലുവിളികളെ മറികടന്ന് ഫലപ്രദമായ നെൽകൃഷിരീതി
വികസിപ്പിച്ചെടുക്കുന്നതിന് ട്രോപ്പിക്കൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് ഇക്കോളജിക്കൽ സയൻസസ്,
നബാർഡിന്റെ പിന്തുണയോടെ നടത്തുന്ന പ്രോജക്റ്റ് ആണിത്.
കാലാവസ്ഥാ മാറ്റം നെൽകൃഷിയിൽ ഉണ്ടാക്കുന്ന പ്രതിസന്ധികൾ മനസ്സിലാക്കി
അതിനു പരിഹാരമായി പ്രാദേശിക കാലാവസ്ഥാ പ്രതിരോധ കൃഷിരീതി
വികസിപ്പിച്ചെടുക്കുകയും അതിനായി നെൽ കർഷകർക്ക്
പരിശിലനം നൽകുകയും ചെയ്യുക എന്നതുമാണ് ഈ പദ്ധതിയുടെ പ്രധാന ഉദ്ദേശം.
കർഷകർ നേരിടുന്ന പ്രശ്നങ്ങൾ അവരിൽ നിന്നും നേരിട്ട് മനസ്സിലാക്കി
അവർക്കിടയിൽ തന്നെയുള്ള ഫലപ്രദമായ രീതികൾ ഏകോപിപ്പിച്ച്
കൂടുതൽ മെച്ചപ്പെട്ട രീതിയിൽ, കാലാവസ്ഥാ മാറ്റങ്ങളെ പ്രതിരോധിക്കാൻ
കഴിവുള്ള ഒരു കൃഷി രീതി കർഷകരിലേക്കെത്തിക്കുക എന്നതാണ് ഇതിലൂടെ ലക്ഷ്യമിടുന്നത്.

ലക്ഷ്യങ്ങൾ

1 കാലാവസ്ഥാമാറ്റം മൂലം നെൽകൃഷിയിൽ ഉള്ള പ്രധാനപ്രശ്നങ്ങൾ
പ്രാധാന്യമനുസരിച്ച് ക്രമീകരിക്കുക
2 നെൽകൃഷി മെച്ചപ്പെടുത്തുന്നതിനായുള്ള ശാസ്ത്രീയവും സാങ്കേതികവുമായ
ഇടപെടലുകളുടെ സ്ഥിതി മനസ്സിലാക്കുക
3 കർഷകർ വികസിപ്പിച്ചെടുത്ത ഫലവത്തായ അനുരൂപീകരണ,
ലഘൂകരണ മാർഗങ്ങൾ ശേഖരിച്ച് കേരളത്തിലെ നെൽകൃഷിയ്ക്ക്
കാലാവസ്ഥാ സൗഹൃദ കൃഷിരീതി വികസിപ്പിച്ചെടുക്കുക.
4 കാലാവസ്ഥാ പ്രതിരോധശേഷിയുള്ള കൃഷിരീതിയുടെ സ്വീകരണത്തിനായി
അറിവ് കൈമാറ്റം ചെയ്യുന്നതിനും ശേഷി വികാസത്തിനും പരിശീലനം നല്കുക

Appendix II

Baseline Survey Questionnaire

TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES (TIES)
www.ties.org.in

Study on Impact of Climate Change on Rice Cultivation in Kerala and Development of Mitigation and Adaptation Strategies

Survey Questionnaire

Questionnaire number:

Date:

Name of the respondent____

Contact number_____________________________ Age __________Gender __________________

Home address ___________________________________ Village______________________________

Village of the paddy field (GPS coordinates) __________________

Full-time/ part-time farmer

Livelihood

Section A - Farm Information and Farming Practices

1. Net Paddy Sown Area:
☐Less than 1 acre
☐1-2 acres
☐2-5 acres
☐More than 5 acres

2. Land Ownership:
☐Fully owned: _________ acres
☐ Owned and leased: _________ acres (Owned), _________ acres (Leased)
☐Fully leased: _________ acres

3. Years of Farming Experience:
☐ Less than 5 years
☐ 5-10 years
☐11-20 years
☐More than 20 years

4. Major Income Sources (Rank)
☐ Rice farming
☐Livestock farming
☐Other crop farming ______________________
☐Off-farm employment
☐Other: ______________________

5. Do you possess debt?
☐ Yes
☐ No

6. Rice Varieties Grown in All Seasons:

Virippu Season:

- Variety: ______________________ | Area: _________ acres

Mundakan Season:

- Variety: ______________________ | Area: _________ acres

Pucha Season:

- Variety: ______________________ | Area: _________ acres

7. Type of Rice Cultivation Method:
☐Traditional
☐System of Rice Intensification (SRI) (Modern)
☐ Organic farming
☐Other: ______________________

8. Method of Sowing:
☐Broadcasting
☐Transplanting
☐Direct seeding
☐Other: ______________________

9. Cropping System:
☐ Mono-cropping
☐ Intercropping
☐Crop rotation ______________________
☐Mixed cropping

10. Source of Water
☐Rainfed
☐Irrigated
☐Both

11. If irrigated, methods used
☐ Flood irrigation
☐Drip irrigation
☐Alternate Wetting and Drying (AWD)
☐Other: ______________________

12. Machineries used (If not, mention alternatives used)

Machinery and number	Owned/rented/group ownership
Tractor	
Tiller	
Cono Weeder	

Sickle	
Plough	
Generator	
Water pump	
Harvester	
Animal power (Bullocks)	
Other	

13. Water Management Practices:
☐Rainwater harvesting
☐Canal irrigation management
☐Use of reservoirs/tanks
☐Alternate Wetting and Drying (AWD)
☐None

14. Pest and Disease Management:
☐Chemical pesticides
☐Organic pesticides
☐Integrated Pest Management (IPM)
☐Biological control methods
☐No specific measures

15. Weed Control:
☐Manual weeding
☐ Chemical herbicides
☐Mulching
☐Crop rotation
☐No specific measures

16. Land Preparation:
☐Ploughing and harrowing
☐Minimum tillage
☐Zero tillage
☐Use of machinery (tractors, tillers)
☐Other: ______________________

17. Fertilizer Application:
☐Chemical fertilizers (NPK)
☐Organic fertilizers (compost, manure)
☐Green manure
☐Bio-fertilizers
☐No fertilizer application

18. Do you process the rice before selling it in the market? If yes, which of the following processing steps do you perform?
☐No processing
☐Drying
☐Dehusking
☐Polishing
☐Milling

Section B- Major challenges

19. Major problems in rice farming

____ Water scarcity

____ Inadequate irrigation infrastructure

____ Pest and disease outbreaks

____ Labor related challenges (Labor shortage, high labor cost, and shortage of skilled labor)

____ Soil degradation

____ Salt water intrusion

____ Market access issues

____ High cost of cultivation

____ Lack of inputs

____ Fluctuating prices

____ Pollution from nearby industries

____ High transportation costs

____ Climate change impacts

- Untimely rain
- Reduced rainfall
- Prolonged drought
- Increased temperature
- Increase in frequency and intensity of extreme events like landslides/floods/droughts

Section C- Climate Adaptation & Mitigation

20. Participation in Climate-Smart Agriculture Training:
☐Yes: Where? What kind? ________________________
☐No

21. Accessibility to Weather Data:
☐Mobile apps
☐Radio/TV broadcasts
☐Government advisories
☐Community networks
☐No access to weather data

22. Social Participation:
☐Yes: Member of 1. SHG 2. Kudumbasree 3. Crop based society (e.g. Padasekhara samithi)

4. Cooperative 5. Other
☐ No

23. Knowledge Sharing Among Farmers:
☐Farmer-to-farmer meetings
☐Through cooperatives or associations
☐Online platforms or social media
☐I don't engage in knowledge sharing

24. Agricultural extension services/policy support to enhance farming knowledge and practices through?
☐Krishi Bhavan
☐ KVK
☐ NGO
☐Other

25. Beneficiary of Support (Specify)
☐ Subsidies
☐Insurance
☐Incentives
☐Schemes
☐Other______________________
☐None

26. Soil and Water Conservation measures followed:
☐Contour bunding
☐Terracing
☐Check dams
☐Cover cropping
☐Rainwater harvesting
☐No specific measures
☐ Other ______________________

27. Climate resilient agriculture practices followed by farmers

Changing the sowing/planting time	
Cultivation of short duration variety	
Diversification of crops (more diversity of crop type) (e.g. switch from 3 to 5 type of crops)	
Crop rotation (number of crops cultivated in a piece of land in a year)	
Variety rotation (Change in variety of crops cultivated in a piece of land in consecutive years)	
Use of drought/flood tolerant crops or varieties	
Change of crop/variety to more resistant one (pest & disease resistant)	
Change to local/traditional variety	
Following intercropping or mixed cropping	
Cultivation of fodder crops	
Crop residue incorporation (instead of burning the crop residue) (in situ/ex situ)	
Practice of Green manuring and cover cropping	
Following System of Rice Intensification i.e. SRI (Alternate wetting and drying)	
Application of bio fertilizers and organic manure	
Use of organic/bio control measures for pest & disease management	
Reduced use of chemical pesticides and fertilizers	
Soil test crop response based fertilizer application (Use of soil health card)	
Split fertilization and site specific application	

Raised bed system of planting	
Deep ploughing of the main field	
Zero Budget Natural Farming	
Building water harvesting structures (pits/ponds/reservoir/rain water harvesting)	
Revival of watershed and village ponds/well recharge	
Minimum tillage or no tillage	
Crop mulching or stubble mulching	
Contour/trench bunding	
Reclamation of cultivable waste land	
Improved irrigation practices (Drip / Programmed irrigation at dusk & dawn / Reused water/sprinkler/ pipeline)	
Agroforestry(Agro pastor/Agri silvi/Agro horticulture) and Replanting in degraded land	
Hydroponics/Aquaponics	
Diversification of farm (dairying/poultry/goatery/bee keeping)	
Use of crop insurance in case of weather vagaries	
Construction of trenches/ponds in forest	
Use of Renewable energy based system (Solar power /water/wind)	
Use of low cost poly house/shade net/rain shelter for multiple crop cultivation	
Community organization to combat weather disasters (seed bank/seed village/fodder bank)	
Homestead farming to conserve agro biodiversity (diverse plant species)	
Planting native tree species	
Manure management (biogas/bio fertilizer use)	
Nutrition management (concentrate/good quality forage/balanced ration)	

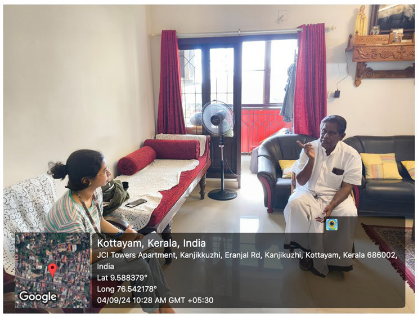
28. What challenges you face in adapting to climate resilient agriculture practices

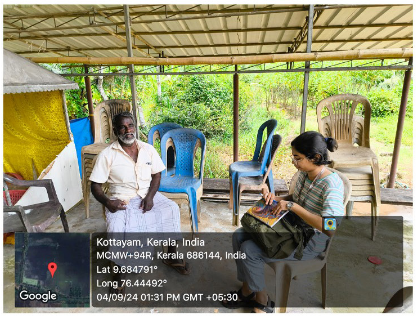
☐ Lack of capital
☐ Lack of information
☐ Lack of access to resources
☐ Other____________________________

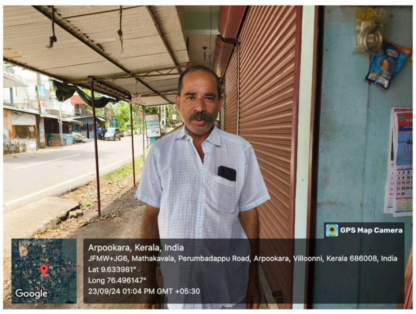
29. What suggestion do you have to effectively adapt to climate related problems

Appendix III
Baseline Survey Participants

Kottayam







Kottayam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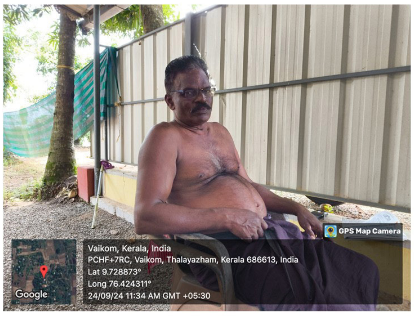
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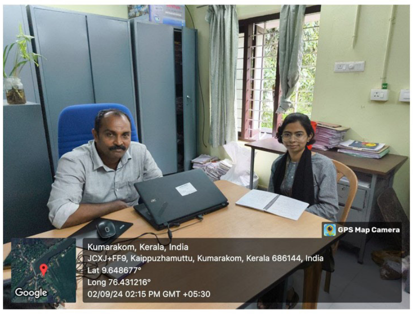
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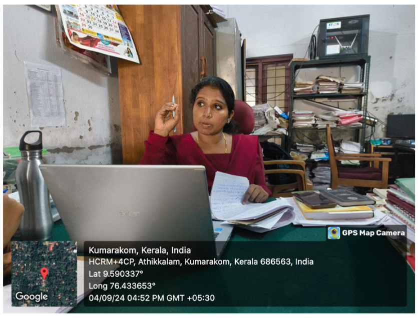
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Alappuzha


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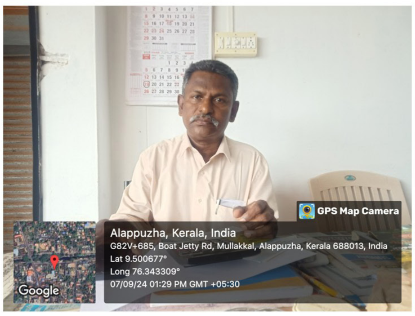
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Alappuzha


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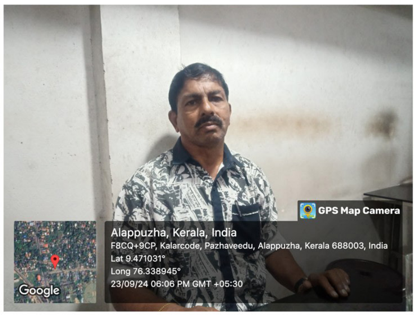
GPS Map Camera
Google
Alappuzha, Kerala, India
F8CQ+9CP, Kalarcode, Pazhaveedu, Alappuzha, Kerala 688003, India
Lat 9.471031°
Long 76.338945°
23/09/24 06:06 PM GMT +05:30


GPS Map Camera
Google
Kavalam, Kerala, India
FFH4+54X, Lisieux-Palliyarakavu Rd, Kavalam, Kuttanad Taluk, Kerala 688506, India
Lat 9.477821°
Long 76.455416°
24/09/24 03:09 PM GMT +05:30


GPS Map Camera
Google
Kavalam, Kerala, India
FFH4+54X, Lisieux-Palliyarakavu Rd, Kavalam, Kuttanad Taluk, Kerala 688506, India
Lat 9.477821°
Long 76.455416°
24/09/24 03:49 PM GMT +05:30


GPS Map Camera
Google
Kavalam, Kerala, India
FFF8+VMR, Kavalam, Kuttanad Taluk, Kerala, India
Lat 9.473305°
Long 76.467083°
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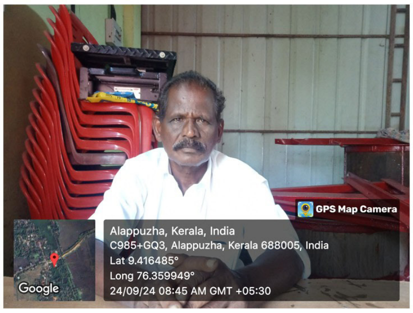
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C985+GQ3, Alappuzha, Kerala 688005, India
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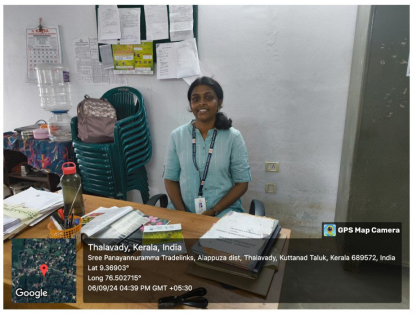
GPS Map Camera
Google
Kavalam, Kerala, India
FFH4+54X, Lisieux-Palliyarakavu Rd, Kavalam, Kuttanad Taluk, Kerala 688506, India
Lat 9.47797°
Long 76.455466°
24/09/24 03:08 PM GMT +05:30


GPS Map Camera
Google
Kuttanad Taluk, Kerala, India
FFFF+XMJ, E Chennamkary Post Office Rd, Kuttanad Taluk, Kerala 686534, India
Lat 9.473316°
Long 76.474925°
24/09/24 11:51 AM GMT +05:30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Sree Panayannuramma Tradelinks, Alappuza dist, Thalavady, Kuttanad Taluk, Kerala 689572, India
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Long 76.502715°
06/09/24 04:39 PM GMT +05:30


GPS Map Camera
Google
Kuttanad Taluk, Kerala, India
9F8G+HVV, Edathua, Kuttanad Taluk, Kerala 689573, India
Lat 9.366552°
Long 76.477109°
06/09/24 02:48 PM GMT +05:30


GPS Map Camera
Google
Kuttanad Taluk, Kerala, India
174/13, near Attuvathala, Pallathuruthy, Ponga, Nedumudy, Kuttanad Taluk, Kerala 688503, India
Lat 9.444032°
Long 76.402613°
06/09/24 01:39 PM GMT +05:30


GPS Map Camera
Google
Kavalam, Kerala, India
FFH4+54X, Lisieux-Palliyarakavu Rd, Kavalam, Kuttanad Taluk, Kerala 688506, India
Lat 9.47797°
Long 76.455466°
24/09/24 03:01 PM GMT +05:30

Palakkad


GPS Map Camera
Alathur, Kerala, India
JHW3+4JC, Krishi Bhavan Rd, Alathur, Kerala 678541, India
Lat 10.645194°
Long 76.554035°
09/09/24 01:16 PM GMT +05:30
Google


GPS Map Camera
Alathur, Kerala, India
JHW2+G94, Alathur, Kerala 678541, India
Lat 10.64649°
Long 76.550449°
09/09/24 11:42 AM GMT +05:30
Google


GPS Map Camera
Palakkad, Kerala, India
Yencees Granite Rd, Kerala, India
Lat 10.710231°
Long 76.651445°
09/09/24 04:25 PM GMT +05:30
Google

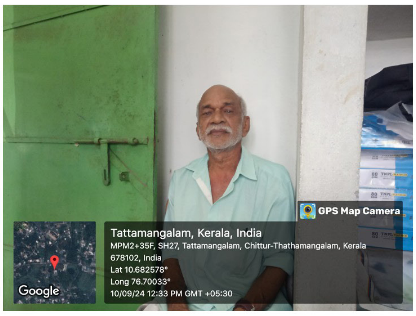

GPS Map Camera
Alathur, Kerala, India
JHW2+G94, Alathur, Kerala 678541, India
Lat 10.64649°
Long 76.550449°
09/09/24 12:08 PM GMT +05:30
Google


GPS Map Camera
Alathur, Kerala, India
JHW3+4JC, Krishi Bhavan Rd, Alathur, Kerala 678541, India
Lat 10.645205°
Long 76.554116°
09/09/24 01:18 PM GMT +05:30
Google


GPS Map Camera
Kannadi-II, Kerala, India
PMC4+RFW, Kannadi-II, Kerala 678501, India
Lat 10.72271°
Long 76.656612°
09/09/24 03:34 PM GMT +05:30
Google


GPS Map Camera
Palakkad, Kerala, India
QPH6+QVQ, Palakkad, Pudussery West, Kerala 678622, India
Lat 10.779201°
Long 76.712456°
10/09/24 11:21 AM GMT +05:30
Google


GPS Map Camera
Tattamangalam, Kerala, India
MPH3+GRG, Devi Nagar Road No. 3, Devi Nagar, Tattamangalam, Chittur-Thathamangalam, Kerala 678102, India
Lat 10.678832°
Long 76.704569°
10/09/24 02:19 PM GMT +05:30
Google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Tattamangalam, Kerala, India
MPM2+35F, SH27, Tattamangalam, Chittur-Thathamangalam, Kerala 678102, India
Lat 10.682578°
Long 76.70033°
10/09/24 12:33 PM GMT +05:30
Google


GPS Map Camera
Palakkad, Kerala, India
HPMG+75W, Palakkad, Kerala 678506, India
Lat 10.585133°
Long 76.726607°
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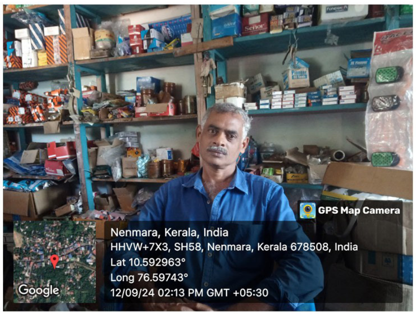
Google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Nenmara, Kerala, India
HHVW+7X3, SH58, Nenmara, Kerala 678508, India
Lat 10.592963°
Long 76.59743°
12/09/24 02:13 PM GMT +05:30
Google


GPS Map Camera
Kombankallu, Kerala, India
HJ85+FWW, Nenmara - Nelliyampathy Rd, Pothundy Dam, Kombankallu, Kerala 678508, India
Lat 10.567182°
Long 76.60968°
12/09/24 12:53 PM GMT +05:30
Google

Palakkad


GPS Map Camera
Kombankallu, Kerala, India
HJ85+6W5, Chemmanthodu, Nenmara - Nelliyampathy Rd, Pothundy, Kombankallu, Kerala 678508, India
Lat 10.565638°
Long 76.609932°
12/09/24 01:12 PM GMT +05:30
Google

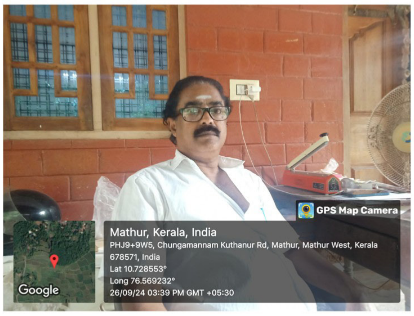

GPS Map Camera
Kombankallu, Kerala, India
HJ85+6W5, Chemmanthodu, Nenmara - Nelliyampathy Rd, Pothundy, Kombankallu, Kerala 678508, India
Lat 10.565638°
Long 76.609932°
12/09/24 01:20 PM GMT +05:30
Google


GPS Map Camera
Kuzhalmannam-I, Kerala, India
MHMF+HP, Kuzhalmannam-I, Kerala 678721, India
Lat 10.682616°
Long 76.573928°
26/09/24 12:11 PM GMT +05:30
Google


GPS Map Camera
Kuzhalmannam, Kerala, India
PH7P+76G, Kottarapadi, Kuzhalmannam, Kuzhalmannam-I, Kerala 678702, India
Lat 10.71273°
Long 76.585485°
26/09/24 12:58 PM GMT +05:30
Google


GPS Map Camera
Kuzhalmannam-I, Kerala, India
MHV9+543, Kuzhalmannam-I, Kerala 678721, India
Lat 10.690715°
Long 76.569083°
26/09/24 12:18 PM GMT +05:30
Google


GPS Map Camera
Mathur, Kerala, India
London Bridge Mathur, Chenganiyur Kavu Rd, Mathur, Mathur West, Kerala 678571, India
Lat 10.746127°
Long 76.560118°
26/09/24 04:53 PM GMT +05:30
Google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Mathur, Kerala, India
PHJ9+9W5, Chungamannam Kuthanur Rd, Mathur, Mathur West, Kerala 678571, India
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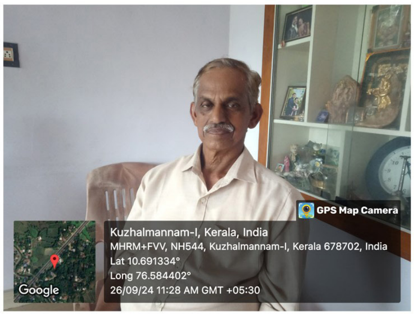
26/09/24 03:39 PM GMT +05:30
Google


GPS Map Camera
Kuzhalmannam-I, Kerala, India
MHRM+FVV, NH544, Kuzhalmannam-I, Kerala 678702, India
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Long 76.584402°
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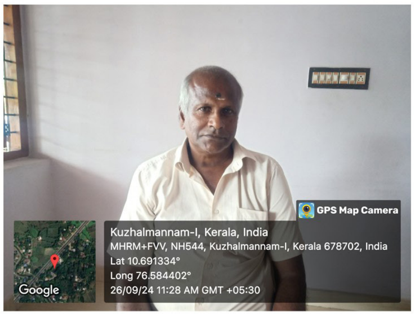
Google


GPS Map Camera
Kuzhalmannam-I, Kerala, India
MHRM+FVV, NH544, Kuzhalmannam-I, Kerala 678702, India
Lat 10.691334°
Long 76.584402°
26/09/24 11:28 AM GMT +05:30
Google


GPS Map Camera
Kuzhalmannam-I, Kerala, India
MHV9+543, Kuzhalmannam-I, Kerala 678721, India
Lat 10.690715°
Long 76.569083°
26/09/24 12:18 PM GMT +05:30
Google


GPS Map Camera
Peringottukurissi, Kerala, India
QF4V+JQ5, Kuzhalmannam - Peringottukurissi Rd, Peringottukurissi, Peringottukurissi South, Kerala 678574, India
Lat 10.756548°
Long 76.494568°
27/09/24 03:26 PM GMT +05:30
Google


GPS Map Camera
Peringottukurissi, Kerala, India
QF4V+JQ5, Kuzhalmannam - Peringottukurissi Rd, Peringottukurissi, Peringottukurissi South, Kerala 678574, India
Lat 10.756557°
Long 76.49452°
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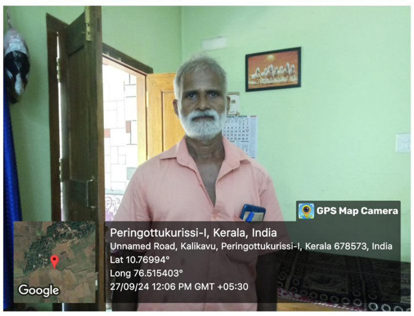
Google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Peringottukurissi-I, Kerala, India
Unnamed Road, Kalikavu, Peringottukurissi-I, Kerala 678573, India
Lat 10.76994°
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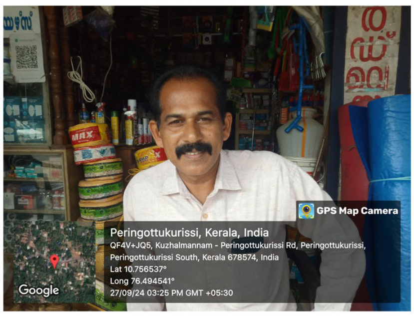
Google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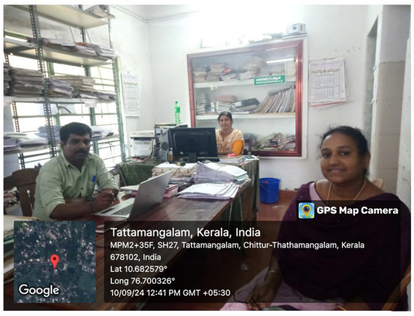
Peringottukurissi, Kerala, India
QF4V+JQ5, Kuzhalmannam - Peringottukurissi Rd, Peringottukurissi, Peringottukurissi South, Kerala 678574, India
Lat 10.756537°
Long 76.494541°
27/09/24 03:25 PM GMT +05:30
Google

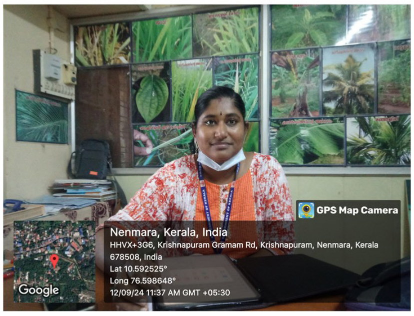

GPS Map Camera
Peringottukurissi, Kerala, India
QF4V+JQ5, Kuzhalmannam - Peringottukurissi Rd, Peringottukurissi, Peringottukurissi South, Kerala 678574, India
Lat 10.756545°
Long 76.494521°
27/09/24 03:26 PM GMT +05:30
Google

Palakkad


GPS Map Camera
Google
Kottayi, Kerala, India
QG9V+7GR, Mankara-Palakkad Rd, Kottayi, Kerala 678572, India
Lat 10.76811°
Long 76.544307°
27/09/24 01:23 PM GMT +05:30


GPS Map Camera
Google
Alathur, Kerala, India
JHW3+4JC, Krishi Bhavan Rd, Alathur, Kerala 678541, India
Lat 10.645383°
Long 76.554098°
09/09/24 12:15 PM GMT +05:30


GPS Map Camera
Google
Tattamangalam, Kerala, India
MPM2+35F, SH27, Tattamangalam, Chittur-Thathamangalam, Kerala 678102, India
Lat 10.682579°
Long 76.700326°
10/09/24 12:41 PM GMT +05:30


GPS Map Camera
Google
Nenmara, Kerala, India
HHVX+3G6, Krishnapuram Gramam Rd, Krishnapuram, Nenmara, Kerala 678508, India
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Long 76.598648°
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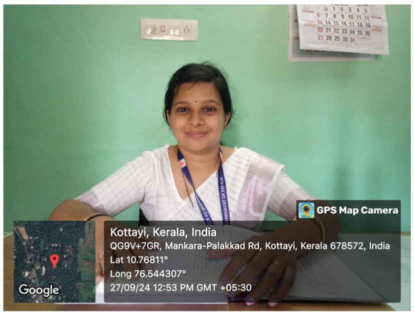
GPS Map Camera
Google
Kottayi, Kerala, India
QG9V+7GR, Mankara-Palakkad Rd, Kottayi, Kerala 678572, India
Lat 10.76811°
Long 76.544307°
27/09/24 12:53 PM GMT +05:30

Thrissur


GPS Map Camera
Thrissur, Kerala, India
G7HM+545, Ayyappankavu Rd, Kozhukkully, Thrissur, Kerala 680751, India
Lat 10.527368°
Long 76.28287°
09/09/24 11:57 AM GMT +05:30
Google


GPS Map Camera
Thrissur, Kerala, India
G7HJ+CV2, Ayyappankavu Rd, Mulayam, Thrissur, Kerala 680751, India
Lat 10.528169°
Long 76.282012°
09/09/24 11:19 AM GMT +05:30
Google


GPS Map Camera
Tholur, Kerala, India
Kolathdu - Mullorkayal - Naduppalam Rd, Tholur, Kerala 680552, India
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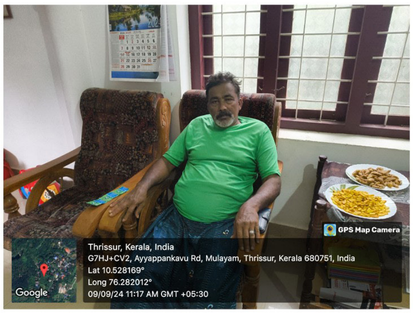
Google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G7HJ+CV2, Ayyappankavu Rd, Mulayam, Thrissur, Kerala 680751, India
Lat 10.528169°
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09/09/24 11:17 AM GMT +05:30
Google


GPS Map Camera
Thrissur, Kerala, India
F4XV+G7C, Udaya Nagar, Thrissur, Arimbur, Kerala 680620, India
Lat 10.498104°
Long 76.14341°
09/09/24 02:58 PM GMT +05:30
Google


GPS Map Camera
Tholur, Kerala, India
H4CH+4X6, Tholur, Parappur, Kerala 680552, India
Lat 10.568919°
Long 76.130727°
09/09/24 05:14 PM GMT +05:30
Google


GPS Map Camera
Mullassery, Kerala, India
G3MW+7MJ, Mullassery, Kerala 680509, India
Lat 10.533132°
Long 76.096823°
09/09/24 03:48 PM GMT +05:30
Google


Mahindra YUVO
GPS Map Camera
Peruvallur, Kerala, India
G4X3+GHP, Penakam, Peruvallur, Kerala 680508, India
Lat 10.549126°
Long 76.104582°
10/09/24 02:44 PM GMT +05:30
Google


GPS Map Camera
Adatt, Kerala, India
G5V3+J5Q, Adatt, Puranattukara, Kerala 680553, India
Lat 10.544022°
Long 76.152433°
10/09/24 11:13 AM GMT +05:30
Google


GPS Map Camera
Thrissur, Kerala, India
H52F+QJC, Adat Rd, Muthuvara, Puzhakkal, Thrissur, Kerala 680553, India
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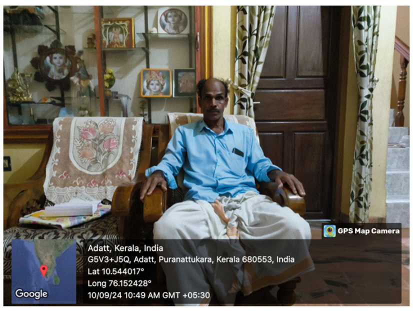
Long 76.174178°
10/09/24 12:11 PM GMT +05:30
Google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Adatt, Kerala, India
G5V3+J5Q, Adatt, Puranattukara, Kerala 680553, India
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Long 76.152428°
10/09/24 10:49 AM GMT +05:30
Google


GPS Map Camera
Thrissur, Kerala, India
H52F+QJC, Adat Rd, Muthuvara, Puzhakkal, Thrissur, Kerala 680553, India
Lat 10.551916°
Long 76.174178°
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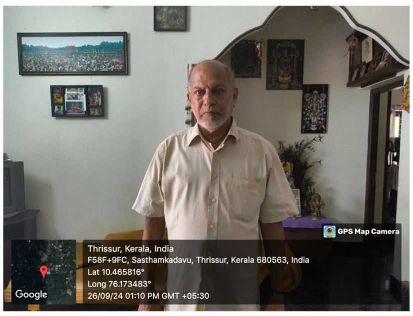
Google


GPS Map Camera
Thrissur, Kerala, India
F58F+9FC, Sasthamkadavu, Thrissur, Kerala 680563, India
Lat 10.465816°
Long 76.173483°
26/09/24 01:10 PM GMT +05:30
Google


GPS Map Camera
Thrissur, Kerala, India
C6J3+MFV, Vallachira, Thrissur, Kerala 680562, India
Lat 10.432486°
Long 76.220506°
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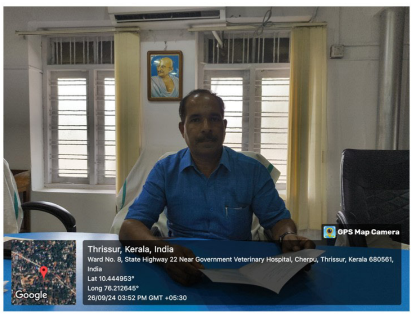
Google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Ward No. 8, State Highway 22 Near Government Veterinary Hospital, Cherpu, Thrissur, Kerala 680561, India
Lat 10.444953°
Long 76.212645°
26/09/24 03:52 PM GMT +05:30
Google

Thrissur


GPS Map Camera
Google
Thrissur, Kerala, India
F52H+RG7, Pallippuram, Thrissur, Kerala 680563, India
Lat 10.452354°
Long 76.17928°
26/09/24 12:28 PM GMT +05:30


GPS Map Camera
Google
Thrissur, Kerala, India
F58C+27X, Kodannur, Thrissur, Kerala 680563, India
Lat 10.46542°
Long 76.170848°
26/09/24 01:41 PM GMT +05:30

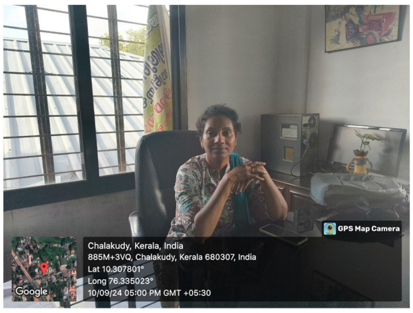

GPS Map Camera
Google
Tholur, Kerala, India
H48F+QWQ, Harisree Nagar, Tholur, Parappur, Kerala 680552, India
Lat 10.56691°
Long 76.12483°
27/09/24 10:06 AM GMT +05:30


GPS Map Camera
Google
Chitilappilly, Kerala, India
H45R+MGV, Mullur Rd, Chitilappilly, Kerala 680551, India
Lat 10.559214°
Long 76.14129°
27/09/24 02:27 PM GMT +05:30


GPS Map Camera
Google
Puranattukara, Kerala, India
H552+CF, Puranattukara, Kerala 680551, India
Lat 10.558445°
Long 76.149933°
27/09/24 03:44 PM GMT +05:30


GPS Map Camera
Google
Chemmanthatta, Kerala, India
236, ward number 7, Pazhunnana, Chemmanthatta, Kerala 680501, India
Lat 10.648398°
Long 76.107809°
27/09/24 11:27 AM GMT +05:30


GPS Map Camera
Google
Chemmanthatta, Kerala, India
J4X5+8Q5, Chemmanthatta, Kerala 680501, India
Lat 10.647983°
Long 76.108902°
27/09/24 12:04 PM GMT +05:30


GPS Map Camera
Google
Chalakudy, Kerala, India
885M+3VQ, Chalakudy, Kerala 680307, India
Lat 10.307801°
Long 76.335023°
10/09/24 05:00 PM GMT +05:30


GPS Map Camera
Google
Tholur, Kerala, India
H48F+WRW, Kaiparambu – Parappur Rd, Harisree Nagar, Tholur, Parappur, Kerala 680552, India
Lat 10.567338°
Long 76.12456°
10/09/24 01:05 PM GMT +05:30

Appendix IV
Malayalam Version Protocol

a - For broadcasted rice

കാലാവസ്ഥാ സൗഹൃദ നെൽകൃഷി പ്രായോഗിക പദ്ധതി

കോട്ടയം, തൃശൂർ, ആലപ്പുഴ, പാലക്കാട് എന്നീ ജില്ലകളിൽ വിജയകരമായി നെൽകൃഷി ചെയ്തുകൊണ്ടിരിക്കുന്ന കർഷകരിൽ നിന്നും ശേഖരിച്ച വിവരങ്ങളുടേയും കാർഷികവിദഗ്ദ്ധരുടെ നിർദ്ദേശങ്ങളുടേയും അടിസ്ഥാനത്തിൽ തയ്യാറാക്കിയത്

കേരളത്തിലെ നെൽകൃഷിയും കാലാവസ്ഥാ മാറ്റവും എന്ന വിഷയത്തെ ആസ്പദമാക്കിയുള്ള പ്രോജക്ടിന്റെ ഭാഗമായി രൂപം കൊടുത്തത്

നടപ്പാക്കുന്നത് : **ട്രോപ്പിക്കൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് ഇക്കോളജിക്കൽ സയൻസസ്**
സഹായസഹകരണം : **നബാർഡ്**

പാടത്ത് അനുവർത്തിക്കേണ്ടത്

ദിവസം	പ്രവർത്തിയുടെ തിയ്യതി രേഖപ്പെടുത്തുക	കാർഷിക പ്രവർത്തി	പ്രവർത്തിയുടെ വിശദാംശം	ശ്രദ്ധിക്കേണ്ട കാര്യങ്ങൾ	പ്രവർത്തി ചെയ്ത തിയ്യതി എഴുതുക
			മണ്ണുപരിശോധന		
വിതയ്ക്ക് മൂന്നാഴ്ച മുമ്പ്		നിലം ഒരുക്കുക	നിലം രണ്ട് തവണ ട്രാക്ടറിൽ ഗേജ് വീൽ വച്ച് തലങ്ങും വിലങ്ങും ഉഴുതു മറിക്കുക. ഒന്നാമത്തെ ഉഴവിനു ശേഷം ഏക്കറിന് 140 കിലോ ഡോളോമേറ്റ് അല്ലെങ്കിൽ 100 കിലോ കുമ്മായം ചേർക്കുക. നാലു ദിവസത്തിനുശേഷം വെള്ളം കയറ്റിയിറക്കുക. രണ്ടാമത്തെ ഉഴവിനു ശേഷം മണ്ണ് പരിശോധനയുടെ അടിസ്ഥാനത്തിൽ ആവശ്യമായ അളവിൽ റോക്ക് ഫോസ്ഫേറ്റ് ചേർക്കുക. ഹെലിക്കൽ പഡ്‌ലർ (helical puddler) കൊണ്ട് നിലം നിരപ്പാക്കുക.		
ഉഴവിനു ശേഷം			പാടത്തെ വെള്ളം പരമാവധി വറ്റിച്ച്, രണ്ടാഴ്ച കള കിളിപ്പിക്കാൻ വിടുക. മുളച്ചു വന്ന കളകൾ ഗ്ലൂഫോസിനേറ്റ് അമ്മോണിയം (Glufosinate ammonium) 8 മില്ലി ഒരു ലിറ്റർ വെള്ളത്തിൽ എന്ന അളവിൽ തളിച്ച് നശിപ്പിക്കുക.		
കളനാശിനി പ്രയോഗത്തിന് 4-5 ദിവസങ്ങൾക്കു ശേഷം			വെള്ളം കയറ്റി നിർത്തുക.		
10 ദിവസങ്ങക്ക് ശേഷം			വെള്ളം വറ്റിക്കുക. അടുത്ത ദിവസം മുമ്പേ തയ്യാറാക്കിയ വിത്ത് വിതക്കുക.	ഒരേക്കറിന് 15-20 കിലോ വിത്ത് വേണം. ഒന്നര കിലോ ഉപ്പ് 10 ലിറ്റർ വെള്ളത്തിലിട്ട് ഉപ്പുലായനി ഉണ്ടാക്കി അതിൽ വിത്ത് മുക്കി, പൊങ്ങിവരുന്ന കേടുള്ള വിത്തുകൾ വേർതിരിക്കുക. ശേഷം വിത്ത് രണ്ട് തവണ നന്നായി വെള്ളത്തിലിട്ട് കഴുകിയെടുക്കുക	

വിത		.	സീഡ് ഡ്രം ഉപയോഗിച്ച് വിതക്കുമ്പോൾ; 800 ഗ്രാം PGPR 2 മിശ്രിതം, 30 ലിറ്റർ വെള്ളത്തിൽ കലക്കി 24 മണിക്കൂർ വിത്ത് മുക്കിവെക്കുക. ശേഷം വിത്ത് വാരി 24 മണിക്കൂർ മൂടി വെക്കുക. വിത്ത് വാപൊട്ടുന്ന സമയത്ത് തന്നെ സീഡ് ഡ്രമ്മിൽ വിതക്കണം. കൂടുതൽ കിളിർപ്പുണ്ടായാൽ സീഡ് ഡ്രമ്മിനുള്ളിൽ വിത്തുകൾ കെട്ടുപിണഞ്ഞിരിക്കും. 1-2 ഇഞ്ച് കനത്തിലുള്ള വെള്ളത്തിൽ വിതക്കുക.	വിത്ത് വിതക്കുന്നതിന്റെ കൂടെ വരമ്പിൽ ചെണ്ടുമല്ലി, ജമന്തി എന്നിവ വിതക്കുന്നത് കീടനിയന്ത്രണത്തിന് സഹായകമാകും.	
വിത്ത് വിതച്ച് 5 ദിവസത്തിന് ശേഷം			വെള്ളം വറ്റിക്കുക		
വിതച്ച് 15 ദിവസങ്ങൾക്കു ശേഷം (കള 2- 3 ഇല പരുവമാവുമ്പോൾ)		കളനാശിനി പ്രയോഗം	1 ലിറ്റർ വിവായയും (Vivaya) 14 ഗ്രാം അഫിനിറ്റി (Affinity) യും 100 ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് തളിക്കുക. കളനാശിനി പ്രയോഗത്തിന് ശേഷം വെള്ളം വറ്റിക്കുക. 48 മണിക്കൂറിന് ശേഷം വെള്ളം കയറ്റുക. വീണ്ടും വെള്ളം വറ്റിച്ച് ആദ്യവള പ്രയോഗം നടത്തുക	വെട്ട് നോസിൽ (Floodjet nozzle) ഉപയോഗിക്കണം. കളനാശിനിയും കീടനാശിനിയും കലക്കാൻ കിണറിലെ വെള്ളം ഉപയോഗിക്കുക	
വിതച്ച് 15 ദിവസങ്ങൾക്കു ശേഷം		ആദ്യ വള പ്രയോഗം	ഒരേക്കറിന് 15 കിലോ യൂറിയ 3 കിലോ വേപ്പിൻ പിണ്ണാക്കിൽ കലർത്തി ചേർക്കുക. 15 കിലോ പൊട്ടാഷ് വളവും ചേർക്കുക.		
വിതച്ച് 20 ദിവസങ്ങൾക്ക് ശേഷം			ലീഫ് കളർ ചാർട്ട് (Leaf Color Chart) ഉപയോഗിച്ച് ഇലയുടെ നിറം ഒത്തുനോക്കി ആവശ്യമായ നൈട്രജൻ വളത്തിന്റെ അളവ് കണ്ടുപിടിക്കുക.		
വിതച്ച് 20 ദിവസങ്ങൾക്ക് ശേഷം		സൂക്ഷ്മ മൂലകം തളിക്കുക	കാർഷിക സർവ്വകലാശാല പുറത്തിറക്കിയ സമ്പൂർണ്ണ എന്ന സൂക്ഷ്മമൂലക മിശ്രിതം 5 ഗ്രാം ഒരു ലിറ്റർ വെള്ളത്തിൽ എന്ന അളവിൽ കലക്കി അടിക്കുക.		
വിതച്ച് 20 22 ദിവസങ്ങൾക്ക് ശേഷം			വെള്ളം വറ്റിക്കുക. വളപ്രയോഗം കഴിഞ്ഞ് 24 മണിക്കൂറിന് ശേഷം വെള്ളം കയറ്റണം. പാടമുണങ്ങുന്ന മുറയ്ക്ക് 10 ദിവസത്തിൻറെ ഇടവേളകളിൽ വെള്ളം കയറ്റിക്കൊണ്ടിരിക്കുക. കൊയ്ത്തിനു 13 ദിവസം മുമ്പ് വരെ ഇത് തുടരുക. ശേഷം ജലസേചനം ആവശ്യമില്ല.		
വിതച്ച് 30 ദിവസങ്ങൾക്ക് ശേഷം		അമ്ലത്വം നിയന്ത്രിക്കുക,	ഏക്കറിന് 100 കിലോ ഡോളോമേറ്റ് അല്ലെങ്കിൽ കുമ്മായം ഇടുക.		
വിതച്ച് 25- 30 ദിവസങ്ങൾക്ക് ശേഷം		തണ്ടുതുരപ്പൻ പുഴുവിന്റെയും ഇലചുരുട്ടി പുഴുവിന്റെയും ആക്രമണം തടയാൻ	ഏക്കറിന് 1 സി സി ജപ്പോണിക്കം, 1 സി സി കിലോണിസ് എന്ന കണക്കിന് ട്രൈക്കോ കാർഡ് വെക്കുക. ശമനമില്ലെങ്കിൽ 100 ലിറ്റർ വെള്ളത്തിൽ 30 മില്ലി കോറാജനൊ (Coragen) ഫെയ്മൊ (Fame) ചേർത്ത് തളിക്കുക	1 സി സി കാർഡ് കീറിയെടുത്ത് പാടത്ത് പലയിടത്തായി വെയ്ക്കുക. കാർഡുകൾ ഓലക്കാലിൽ കുത്തിവെക്കുകയോ സ്റ്റാപ്പിൾ ചെയ്തു വെക്കുകയോ ചെയ്യാം. ആവശ്യാനുസരണം 6 മുതൽ 8 കാർഡ് വരെ ഉപയോഗിക്കാം. ഡിസ്പോസിബിൾ കപ്പുകൊണ്ട് മൂടി മഴയിൽ നിന്നും സംരക്ഷണം നൽകുക.	

വിതച്ച് 30 ദി വസങ്ങൾക്ക് ശേഷം		ഓല കരി ച്ചിൽ നിയ ന്ത്രണം	ബ്ലീച്ചിംഗ് പൌഡർ കിഴികെട്ടി തൂമ്പ് തുറക്കുന്നിടത്ത് വെക്കു ന്നത് ഓല കരിച്ചിൽ നിയന്ത്രിക്കാൻ സഹായകരമാകും. ഓ ല കരിച്ചിൽ കാണപ്പെടുകയാണെങ്കിൽ വിദഗ്ദ്ധ ഉപദേശത്തി ന്റെ അടിസ്ഥാനത്തിൽ ഊസ് ടെസ്റ്റ് (Ooze test) ചെയ്ത് രോഗകീടം ബാക്ടീരിയ തന്നെയാണെന്ന് ഉറപ്പുവരുത്തുക. ഓലകരിച്ചിൽ നിയന്ത്രിക്കാൻ 20 ഗ്രാം ചാണകം ഒരു ലിറ്റർ വെള്ളത്തിൽ കലക്കി അതിന്റെ തെളിവെള്ളം തളിക്കുന്നതും, 5 ഗ്രാം സ്യൂഡോമൊണാസ് ഒരു ലിറ്റർ വെള്ളത്തിൽ കലക്കി തളിക്കുന്നതും നല്ലതാണ്. ശമനമില്ലെങ്കിൽ ഏക്കറിന് 30 ഗ്രാം ടാഗ്മൈസിനും (Tagmycin) 50 ഗ്രാം നേറ്റീവോയും (Nativo) 20 ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് തളിക്കാവുന്നതാണ്.		
വിതച്ച് 30 മുതൽ 35 ദി വസങ്ങൾക്ക് ശേഷം		രണ്ടാം വളപ്ര യോഗം	ഏക്കറിന് 25 കിലോ യൂറിയ, 20 കിലോ പൊട്ടാഷ് വളം എന്നിവ ചേർക്കുക.		
വിതച്ച് 50 ദി വസങ്ങൾക്ക് ശേഷം		സൂക്ഷ്മ മൂലകം തളിക്കുക	സമ്പൂർണ്ണ 10 ഗ്രാം ഒരു ലിറ്റർ വെള്ളത്തിൽ തളിക്കുക		
വിതച്ച് 55 ദി വസങ്ങൾക്ക് ശേഷം		മൂന്നാം വളപ്ര യോഗം	ഏക്കറിന് 20 കിലോ യൂറിയ, 25 കിലോ പൊട്ടാഷ് വളം എന്നിവ ചേർക്കുക		
		കീട രോഗ നിരീ ക്ഷണം നടത്തുക	കീട രോഗബാധ സാരമായി കാണുന്ന മുറയ്ക്ക് നിയന്ത്രണം അനുവർത്തിക്കുക . ബ്ലാസ്റ്റിന് (Blast) ഏക്കറിന് 80 ഗ്രാം നേറ്റീവോ (Nativo) 200 ലിറ്റർ വെള്ളത്തിൻ ചേർത്ത് തളിക്കുക. കുഴൽപുഴു ബാധയുള്ള ചെടികൾക്ക് കുറുകെ, മണ്ണെണ്ണ യിൽ മുക്കിയ കയർ പിടിച്ച് ചെടികളുടെ മുകളിൽകൂടി കുഴൽപുഴു താഴെ വീഴും തക്കവണ്ണം വലിക്കുക. ശേഷം വെള്ളം വറ്റിക്കുക . നിലത്തു വീണ പുഴുക്കളെ പെറുക്കി നശിപ്പിക്കുക. പട്ടാളപുഴുവിനെ നിയന്ത്രിക്കാനായി 7 മുതൽ 14 ദിവസം വരെ വെള്ളം കയറ്റിയിടുക. മുഞ്ഞ, ഇലപ്പേൻ എന്നിവക്കെതിരെ 3 - 4 മില്ലി നിമ്പിസിടിൻ (Nimbicidine)- ഒരു ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് തളിക്കുക	ആദ്യം രോഗബാധ യുള്ളയിടങ്ങളെ വേർതിരിച്ച് അവിടെ മാത്രം അടിക്കുക. ആവശ്യമെങ്കിൽ മാത്രം മറ്റിടങ്ങളിൽ വ്യാപിപ്പിക്കുക.	
വിതച്ച് 55 - 60 ദിവസങ്ങൾക്ക് ശേഷം (വരി കതിരിടുന്ന സമയത്ത്)		വരി നിയ ന്ത്രണം	കേരള കാർഷിക സർവ്വകലാശാല വികസിപ്പിച്ചെടുത്ത വീഡ് വൈപ്പർ (Weed wiper) എന്ന ഉപകരണം ഉപയോഗിച്ച് വരിനെ ല്ലിന്റെകതിരുകൾ കളനാശിനി, ഗ്ലൂഫോസിനേറ്റ് അമ്മോണിയം (Glufosinate ammonium) - 100 മില്ലി ഒരു ലിറ്റർ വെള്ളത്തിൽ ഉപയോഗിച്ച് ഉണക്കിക്കളയാം.		
		ചാഴി യുടെ ആക്രമ ണം കാ ണുന്ന മുറയ്ക്ക്	15 മില്ലി ഫിഷ് അമിനോ ആസിഡ് (Fish amino acid) ഒരു ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് ചാഴി ബാധയുള്ള ചെടികൾ ക്ക് ചുറ്റിലും അടിക്കുക. എന്നിട്ട് ഉൾഭാഗങ്ങളിലോട്ട് അടി ച്ചു വരിക. പരാഗണം നടക്കുന്നതിനാൽ രാവിലെയോ വൈകുന്നേരങ്ങളിലോ തളിക്കുക.		

നട്ട് 120 ദിവസങ്ങൾക്ക് ശേഷം		വിളവെടുപ്പ്	85 % കതിരുകൾ വിളഞ്ഞുകഴിഞ്ഞാൽ വിളവെടുപ്പ് നടത്തുക	ന്യായമായ കൊയ്ത്തുകൂലി ഏജന്റുമായി മുൻകൂട്ടി തീരുമാനിച്ച് കരാർ ഉണ്ടാക്കുക. കുബോട്ട (Kubota), യന്മാർ (Yanmar) പോലുള്ള കനം കുറഞ്ഞ കൊയ്ത്തുയന്ത്രങ്ങൾ ഉപയോഗിക്കുകയാണെങ്കിൽ നിലം താഴ്ന്നുപോകുന്നത് തടയാനാകും. നീളമുള്ള ഹാൻഡിൽ ഉള്ള മെഷീൻ ആണെങ്കിൽ കൊയ്തെടുത്ത നെല്ല് നേരെ ചാക്കിൽ നിറക്കാനാവും.	
		ഇൻഷുറൻസ്	വിത്ത് നട്ട് 45 ദിവസത്തിനുള്ളിൽ സംസ്ഥാന സർക്കാരിന്റെ വിള ഇൻഷുറൻസ് പദ്ധതി പ്രകാരം ഓൺലൈൻ വഴി നെല്ല് ഇൻഷ്വർ ചെയ്യുക. വിളനാശം വന്നാൽ കാലതാമസം കൂടാതെ കൃഷിഭവനിൽ അറിയിക്കുക. കേന്ദ്ര ഗവണ്മെന്റിന്റെ കാലവസ്ഥായധിഷ്ഠിത വിള ഇൻഷുറൻസിന്റെ അറിയിപ്പ് വരുമ്പോൾ ഓൺലൈൻ വഴി സ്വന്തമായോ ഇൻഷുറൻസ് ഏജന്റിന്റെ സഹായത്താലോ വിള ഇൻഷ്വർ ചെയ്യുക		

Study on Impact of Climate Change on Rice Cultivation in Kerala and Development of Mitigation and Adaptation Strategies

A PROJECT BY
TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES

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ട്രോപ്പിക്കൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് ഇക്കോളജിക്കൽ സയൻസസ്
ഇക്കോളജിക്കൽ റിസർച്ച് കാമ്പസ്
വെള്ളൂർ പി.ഓ. പാമ്പാടി, കോട്ടയം, കേരളം. പിൻ - 686 501
മഹാത്മാഗാന്ധി യൂണിവേഴ്സിറ്റിയുടെ അംഗീകൃത ഗവേഷണകേന്ദ്രം
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Appendix IV

Malayalam Version Protocol

b - For transplanted rice

കാലാവസ്ഥാ സൗഹൃദ നെൽകൃഷി പ്രായോഗിക പദ്ധതി

കോട്ടയം, തൃശൂർ, ആലപ്പുഴ, പാലക്കാട് എന്നീ ജില്ലകളിൽ വിജയകരമായി നെൽകൃഷി ചെയ്തുകൊണ്ടിരിക്കുന്ന കർഷകരിൽ നിന്നും ശേഖരിച്ച വിവരങ്ങളുടേയും കാർഷികവിദഗ്ദ്ധരുടെ നിർദ്ദേശങ്ങളുടേയും അടിസ്ഥാനത്തിൽ തയ്യാറാക്കിയത്

കേരളത്തിലെ നെൽകൃഷിയും കാലാവസ്ഥാ മാറ്റവും എന്ന വിഷയത്തെ ആസ്പദമാക്കിയുള്ള പ്രോജക്റ്റിന്റെ ഭാഗമായി രൂപം കൊടുത്തത്

നടപ്പാക്കുന്നത് : **ട്രോപ്പിക്കൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് ഇക്കോളജിക്കൽ സയൻസസ്**
സഹായസഹകരണം : **നബാർഡ്**

നഴ്സറി(ഞാറ്റടി)യിൽ അനുവർത്തിക്കേണ്ടത്

ദിവസം	തിയ്യതി ആദ്യം തന്നെ രേഖപ്പെടുത്തുക	കാർഷിക പ്രവർത്തി	പ്രവർത്തിയുടെ വിശദാംശം	ശ്രദ്ധിക്കേണ്ട കാര്യങ്ങൾ	പ്രവർത്തി ചെയ്ത തിയ്യതി എഴുതുക
			മണ്ണുപരിശോധന		
വിത്ത് പാകുന്നതിനു 2 ദിവസം മുമ്പ്		നഴ്സറി (ഞാറ്റടി) തയ്യാറാക്കുക	നിലം ഉഴുത് ചളിയാക്കി നിരത്തുക. പലക കൊണ്ട് നിരപ്പാക്കുക.		
വിത്ത് പാകുന്നതിനു 2 ദിവസം മുമ്പ്			വിത്ത് വെള്ളത്തിലിട്ട് 12-48 മണിക്കൂർ കുതിരാൻ അനുവദിക്കുക. തുടർന്ന് വിത്ത് വാരി മുളക്കാൻ വെക്കുക. വിത്ത് PGPR 2 മിശ്രിതത്തിൽ ഏക്കറിന് 800 ഗ്രാം എന്ന തോതിൽ കലർത്തി വിതക്കുക.	ഒരേക്കറിന് 30 കിലോ വിത്ത് വേണം. ഒന്നര കിലോ ഉപ്പ് 10 ലിറ്റർ വെള്ളത്തിലിട്ട് ഉപ്പുലായനി ഉണ്ടാക്കി അതിൽ വിത്ത് മുക്കി, പൊങ്ങിവരുന്ന കേടുള്ള വിത്തുകൾ വേർതിരിക്കുക. വിത്ത് വിതക്കുന്നതിന്റെ കൂടെ വരമ്പിൽ ചെണ്ടുമല്ലി, ജമന്തി എന്നിവ വിതക്കുന്നത് കീടനിയന്ത്രണത്തിന് സഹായകമാകും.	
വിത്ത് പാകി 15-20 ദിവസത്തിന് ശേഷം		1% യൂറിയ ലായനി തളിക്കുക	10 ഗ്രാം യൂറിയ ഒരു ലിറ്റർ വെള്ളത്തിൽ കലക്കി തളിക്കുക		
പറിച്ചു നടുന്നതിന് ഒരു ദിവസം മുമ്പ്		സ്യൂഡോമൊണാസ് തളിക്കുക	സ്യൂഡോമൊണാസ് 20 ഗ്രാം ഒരു ലിറ്റർ വെള്ളത്തിൽ എന്ന അളവിൽ തളിക്കുക		
വിത്ത് പാകി 21-24 ദിവസത്തിനുള്ളിൽ		പറിച്ചു നടുക	വേരുകൾക്ക് നാശം സംഭവിക്കാതെ പറിച്ചു നടുക		

പാടത്ത് അനുവർത്തിക്കേണ്ടത്

പറിച്ചു നടുന്നതിന് മൂന്നാഴ്ച മുമ്പ്		നിലം ഒരുക്കുക	നിലം രണ്ട് തവണ ട്രാക്ടറിൽ കേജ് വീൽ വച്ച് തലങ്ങും വിലങ്ങും ഉഴുതു മറിക്കുക. ഒന്നാമത്തെ ഉഴവിനു ശേഷം ഏക്കറിന് 140 കിലോ ഡോളോമേറ്റ് അല്ലെങ്കിൽ 100 കിലോ കുമ്മായം ചേർക്കുക. നാല് ദിവസത്തിന് ശേഷം വെള്ളം കയറ്റിയിറക്കുക. ശേഷം ഏക്കറിന് 100 കിലോ എന്ന കണക്കിൽ കമ്പോസ്റ്റ് ഇടുക. രണ്ടാമത്തെ ഉഴവിനു ശേഷം മണ്ണ് പരിശോധനയുടെ അടിസ്ഥാനത്തിൽ ആവശ്യമായ അളവിൽ റോക്ക് ഫോസ്ഫേറ്റ് ചേർക്കുക. ഹെലിക്കൽ പട്ലർ കൊണ്ട് നിലം നിരപ്പാക്കുക.		
ഉഴവിനു ശേഷം			പാടത്തെ വെള്ളം പരമാവധി വറ്റിച്ച്, വിതക്കാതെ രണ്ടാഴ്ച കള കിളിപ്പിക്കാൻ വിടുക. ശേഷം വെള്ളം കയറ്റി നിർത്തുക.		
നടുന്നതിന് ഒരു ദിവസം മുമ്പ്			വെള്ളം വറ്റിക്കുക. വരിനെല്ലുള്ള പാടങ്ങളിൽ വെള്ളം വറ്റിച്ച് തീരുന്നതിനു മുമ്പ് ചെറിയ ഒരു ജലപടലം നിലനിർത്തി 3 മില്ലി ഓക്സിഫ്ളർഫെൻ (Oxyfluorfen) ഒരു ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് തളിക്കുക. അടുത്ത ദിവസം പറിച്ചുനടുക.		
വിത്ത് പാകി 21- 24 ദിവസങ്ങൾക്കുള്ളിൽ		പറിച്ചു നടൽ	നിലം നന്നായി ചളിയാക്കി നിരത്തുക. ഞാറു വരിവരിയായി നടാൻ ശ്രദ്ധിക്കുക. ചെടികൾ തമ്മിൽ 15- 20 സെ.മീ അകലം നിലനിർത്തുക. ഓരോ മൂന്ന് മീറ്റർ കഴിയുമ്പോഴും ഒരടി വീതിയിൽ നിരയിടുക (വളമിടാനും മറ്റും).		
നട്ട് 5 ദിവസത്തിന് ശേഷം		ആദ്യ വള പ്രയോഗം	ഏക്കറിന് 14 കിലോ യൂറിയ 3 കിലോ വേപ്പിൻ പിണ്ണാക്കിൽ ചേർത്ത് ഉടൻ ഇടുക. 15 കിലോ പൊട്ടാഷ് വളവും ചേർക്കുക. വളത്തിന്റെ കൂടെ കളനാശിനി ലോൺഡാക്സ് പവർ (Londax power) ഏക്കറിന് 4 കിലോ എന്ന അളവിൽ ചേർത്തിടുക.	വളപ്രയോഗം കഴിഞ്ഞ് 24 മണിക്കൂറിന് ശേഷം വെള്ളം കയറ്റണം. പാടമുണങ്ങുന്ന മുറയ്ക്ക്, ചിനപ്പ് പൊട്ടുന്ന സമയത്തൊഴികെ 10 ദിവസത്തിൻറെ ഇടവേളകളിൽ വെള്ളം കയറ്റിക്കൊണ്ടിരിക്കുക. കൊയ്ത്തിനു 13 ദിവസം മുമ്പ് വരെ ഇത് തുടരുക. ശേഷം ജലസേചനം ആവശ്യമില്ല.	
നട്ട് 20 ദിവസങ്ങൾക്ക് ശേഷം			ലീഫ് കളർ ചാർട്ട് (Leaf Color Chart) ഉപയോഗിച്ച് ഇലയുടെ നിറം ഒത്തുനോക്കി ആവശ്യമായ നൈട്രജൻ വളത്തിന്റെ അളവ് കണ്ടുപിടിക്കുക.		
നട്ട് 25 ദിവസങ്ങൾക്ക് ശേഷം		രണ്ടാം വള പ്രയോഗം	ഏക്കറിന് 25 കിലോ യൂറിയയും 15 കിലോ പൊട്ടാഷ് വളവും ചേർക്കുക.		

നട്ട് 30 ദിവസങ്ങൾക്ക് ശേഷം		അമ്ലത്വം നിയന്ത്രിക്കുക, സൂക്ഷ്മ മൂലകം തളിക്കുക	ഏക്കറിന് 100 കിലോ ഡോളോമേറ്റ് അല്ലെങ്കിൽ കുമ്മായം ഇടുക. കാർഷിക സർവ്വകലാശാല പുറത്തിറക്കിയ സമ്പൂർണ്ണ എന്ന സൂക്ഷ്മമൂലക മിശ്രിതം 10 ഗ്രാം ഒരു ലിറ്റർ വെള്ളത്തിൽ എന്ന അളവിൽ കലക്കി അടിക്കുക.		
നട്ട് 25 - 30 ദിവസങ്ങൾക്ക് ശേഷം		തണ്ടുതുരപ്പൻ പുഴുവിന്റെയും ഇലചുരുട്ടി പുഴുവിന്റെയും ആക്രമണം തടയാൻ	ഏക്കറിന് 1 CC ജപ്പോണിക്കം, 1 CC കിലോണിസ് എന്ന കണക്കിന് ട്രൈക്കോ കാർഡ് വെക്കുക. രോഗ ബാധ കാണുകയാണെങ്കിൽ വായാഗോ (Vayego) ഏക്കറിന് 80 മില്ലി എന്ന അളവിൽ അടിക്കുക.	1 CC കാർഡ് കീറിയെടുത്ത് പാടത്ത് അവിടിവുടായി വെച്ച് കൊടുക്കുക. കാർഡുകൾ ഓലക്കാലിൽ കുത്തിവെക്കുകയോ സ്റ്റാപ്പിൾ ചെയ്തു വെക്കുകയോ ചെയ്യാം. ആവശ്യാനുസരണം 6 മുതൽ 8 കാർഡ് വരെ ഉപയോഗിക്കാം. ഡിസ്പോസിബിൾ കപ്പുകൊണ്ട് മൂടി മഴയിൽ നിന്നും സംരക്ഷണം നൽകുക.	
നട്ട് 30 ദിവസങ്ങൾക്ക് ശേഷം		ഓലകരിച്ചിൽ നിയന്ത്രണം	ബ്ലീച്ചിംഗ് പൌഡർ കിഴികെട്ടി തൂമ്പ് തുറക്കുന്നിടത്ത് വെക്കുന്നത് ഓലകരിച്ചിൽ നിയന്ത്രിക്കാൻ സഹായകരമാകും. ഓലകരിച്ചിൽ കാണപ്പെടുകയാനെങ്കിൽ വിദഗ്ദ്ധ ഉപദേശത്തിന്റെ അടിസ്ഥാനത്തിൽ ഊസ് ടെസ്റ്റ് (Ooze test) ചെയ്ത് രോഗകീടം ബാക്ടീരിയ തന്നെയാണെന്ന് ഉറപ്പുവരുത്തുക. ഓലകരിച്ചിൽ നിയന്ത്രിക്കാൻ 20 ഗ്രാം ചാണകം വെള്ളത്തിൽ കലക്കി ഒരു ലിറ്റർ ചാണകത്തെളി ഉണ്ടാക്കി അതിലേക്ക് 20 ഗ്രാം സ്യൂഡോമൊണാസ് കലക്കി തളിക്കുന്നതും നല്ലതാണ്. രോഗ ബാധ രൂക്ഷമാവുകയാണെങ്കിൽ ഏക്കറിന് 30 ഗ്രാം ടാഗ്മൈസിനും (Tagmycin) 50 ഗ്രാം നേറ്റീവോയും (Nativo) 20 ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് തളിക്കാവുന്നതാണ്.		
നട്ട് 50 ദിവസങ്ങൾക്ക് ശേഷം		മൂന്നാം വളപ്രയോഗം	ഏക്കറിന് 25 കിലോ യൂറിയ, 15 കിലോ പൊട്ടാഷ് വളം എന്നിവ ചേർക്കുക.		
നട്ട് 50 ദിവസങ്ങൾക്ക് ശേഷം		സൂക്ഷ്മ മൂലകം തളിക്കുക	സമ്പൂർണ്ണ 10 ഗ്രാം ഒരു ലിറ്റർ വെള്ളത്തിൽ തളിക്കുക		
		കീട രോഗ നിരീക്ഷണം നടത്തുക	കീട രോഗബാധ സാരമായി കാണുന്ന മുറയ്ക്ക് നിയന്ത്രണം അനുവർത്തിക്കുക. ബ്ലാസ്റ്റിന് (Blast) ഏക്കറിന് 80 ഗ്രാം നേറ്റീവോ (Nativo) 200 ലിറ്റർ വെള്ളത്തിൻ ചേർത്ത് തളിക്കുക. മുഞ്ഞ, ഇലപ്പേൻ എന്നിവക്കെതിരെ 3 - 4 മില്ലി നിമ്പിസിടിൻ (Nimbicidine)- ഒരു ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് തളിക്കുക.	ആദ്യം രോഗബാധയുള്ളയിടങ്ങളെ വേർതിരിച്ച് അവിടെ മാത്രം അടിക്കുക. ആവശ്യമെങ്കിൽ മാത്രം മറ്റിടങ്ങളിൽ വ്യാപിപ്പിക്കുക.	

വരി കതിരി ടുന്ന സമയ ത്ത്		വരി നിയ ന്ത്രണം	കേരള കാർഷിക സർവ്വകലാശാല വികസി പ്പിച്ചെടുത്ത വീഡ് വൈപ്പർ (Weed wiper) എന്ന ഉപകരണം ഉപയോഗിച്ച് വരിനെല്ലിന്റെ കതിരു കൾ കളനാശിനി, ഗ്ലൂഫോസിനേറ്റ് അമ്മോണിയം (Glufosinate ammonium) - 100 മില്ലി ഒരു ലിറ്റർ വെള്ളത്തിൽ ഉപയോഗിച്ച് ഉണക്കിക്കളയാം.		
		ചാഴിയുടെ ആക്രമ ണം കാ ണുന്ന മുറ യ്ക്ക്	15 മില്ലി ഫിഷ് അമിനോ ആസിഡ് (Fish amino acid) ഒരു ലിറ്റർ വെള്ളത്തിൽ ചേർത്ത് ചാഴി ബാധയുള്ള ചെടികൾക്ക് ചുറ്റിലും അടിക്കുക. എന്നിട്ട് ഉൾഭാഗങ്ങളിലോട്ട് അടിച്ചു വരിക. പരാഗണം നടക്കുന്നതിനാൽ രാവിലെയോ വൈകുന്നേരങ്ങളിലോ തളിക്കുക.		
നട്ട് 95 - 100 ദിവസങ്ങൾ ക്ക് ശേഷം		വിളവെ ടുപ്പ്	85 % കതിരുകൾ വിളഞ്ഞുകഴിഞ്ഞാൽ വിളവെടുപ്പ് നടത്തുക.	ന്യായമായ കൊയ്ത്തു കൂലി ഏജന്റുമായി മുൻ കൂട്ടി തീരുമാനിച്ച് കരാർ ഉണ്ടാക്കുക. കുബോട്ട (Kubota), യന്മാർ (Yanmar) പോലുള്ള കനം കു റഞ്ഞ കൊയ്ത്തുയന്ത്ര ങ്ങൾ ഉപയോഗിക്കുക യാണെങ്കിൽ നിലം താ ഴ്ന്നുപോകുന്നത് തടയാ നാകും. നീളമുള്ള ഹാൻ ഡിൽ ഉള്ള മെഷീൻ ആണെങ്കിൽ കൊയ് തെടുത്ത നെല്ല് നേരെ ചാക്കിൽ നിറക്കാനാവും.	
		ഇൻഷുറ ൻസ്	വിത്ത് നട്ട് 45 ദിവസത്തിനുള്ളിൽ സംസ്ഥാന സർക്കാരിന്റെ വിള ഇൻഷുറൻസ് പദ്ധതി പ്രകാ രം ഓൺലൈൻ വഴി നെല്ല് ഇൻഷ്വർ ചെയ്യുക. വിളനാശം വന്നാൽ കാലതാമസം കൂടാതെ കൃഷി ഭവനിൽ അറിയിക്കുക. കേന്ദ്ര ഗവണ്മെന്റിന്റെ കാലവസ്ഥായധിഷ്ഠിത വിള ഇൻഷുറൻസിൻറെ അറിയിപ്പ് വരുമ്പോൾ ഓൺലൈൻ വഴി സ്വന്തമായോ ഇൻഷുറൻസ് ഏജന്റിന്റെ സഹായത്താലോ വിള ഇൻഷ്വർ ചെയ്യുക.	www.pmfby.gov.in	

Appendix IV

Plant Protection Inputs Recommended in the Climate Resilient Farming Protocol

a - Herbicides

Parameter	Vivaya	Affinity	Goal	Londax Power	Basta
Type of Herbicide	Post-emergence	Post-emergence	Pre-emergence and early post-emergence	Broad-spectrum (pre- and post-emergence)	Non-selective, contact herbicide
Formulation Type	OD (Oil Dispersible)	WG (Water Dispersible Granule)	EC (Emulsifiable Concentrate)	WG (Water Dispersible Granule)	SL (Soluble Liquid)
Active Ingredient(s)	Penoxsulam 1.02%, Cyhalofop-butyl 5.1%	Carfentrazone-ethyl	Oxyfluorfen 23.5%	Bensulfuron-methyl + Penoxsulam	Glufosinate Ammonium 13.5%
Mode of Action	ALS (Acetolactate Synthase) inhibitor + ACCase (Acetyl-CoA Carboxylase) inhibitor	PPO (Protoporphyrinogen Oxidase) inhibitor	PPO (Protoporphyrinogen Oxidase) inhibitor	ALS + ACCase inhibitor	GS (Glutamine Synthetase) inhibitor
Target Weeds	Grasses, broadleaf weeds, sedges (Cyperus spp.)	Broadleaf weeds and sedges	Broadleaf and some grassy weeds	Grasses, broadleaf weeds, sedges	All green vegetation (non-selective)
Application Timing	3–4 leaf stage or 15 DAT (Days After Transplanting)	After emergence of broadleaf weeds	Pre- to early post-emergence	Early post-emergence	When weeds are actively growing
Dosage per Hectare	2000–2250 mL	50 g	750–1000 mL	10 kg	2.5–3.75 L
Toxicity Classification	Blue Label (Moderately toxic)	Green Label (Slightly toxic)	Blue Label (Moderately toxic)	Blue Label (Moderately toxic)	Blue Label (Moderately toxic)
Key Benefits	Broad-spectrum, systemic, dual mode of action	Quick action (48–72 hours), selective	Long-lasting soil activity, strong on broadleaves	Dual mode of action, good on sedges	Rapid weed kill, rainfast, suitable for desiccation

b - Insecticides

Parameter	Vayego	Fame	Coragen
Formulation Type	SC (Suspension Concentrate)	SC (Suspension Concentrate)	SC (Suspension Concentrate)
Active Ingredient(s)	Tetraniliprole 18.8%	Flubendiamide 48%	Chlorantraniliprole 18.5%
Mode of Action	RyR (Ryanodine Receptor) modulator	RyR modulator	RyR modulator
Target Pests	Yellow stem borer, leaf folder, beetles, miners	Stem borers, caterpillars, leaf folders	Yellow stem borer, leaf folders, caterpillars
Application Timing	Early infestation stage	Early larval stage	Egg hatch or early larva
Dosage per Hectare	250–300 mL	100–150 mL	150–170 mL
Toxicity Classification	Blue Label (Moderately toxic)	Green Label (Slightly toxic)	Green Label (Slightly toxic)
Key Benefits	Fast acting, long residual, rainfast	Excellent on borers, low residue	Broad pest coverage, systemic protection

c - Fungicide and Bactericide

Parameter	Nativo (Fungicide)	Tagmycin (Bactericide)
Formulation Type	WG (Water Dispersible Granule)	SL (Soluble Liquid)
Active Ingredient(s)	Tebuconazole 50%, Trifloxystrobin 25%	Streptomycin Sulphate
Mode of Action	DMI (Demethylation Inhibitor) + QoI (Quinone outside Inhibitor)	Protein synthesis inhibitor
Target Diseases	Blast, sheath blight, neck blast, dirty panicle, false smut	Bacterial leaf blight, wilt
Application Timing	Preventive or early curative	Early symptom appearance
Dosage per Hectare	200–400 g in 375–500 L water	100–200 g
Toxicity Classification	Blue Label (Moderately toxic)	Green Label (Slightly toxic)
Key Benefits	Resistance management, improved yield and quality	Controls bacterial pathogens in rice

d - Bio-formulations

Parameter	Nimbicidine (Biopesticide)	Fish Amino Acid (Bio-stimulant)
Formulation Type	EC (Emulsifiable Concentrate)	Liquid
Active Ingredient(s)	Azadirachtin 0.03%	Hydrolyzed fish protein and amino acids
Mode of Action	IGR (Insect Growth Regulator), anti-feedant	Nutrient enrichment, microbial stimulation, odor-based aphid repellency
Target Pests / Issues	Aphids, thrips, whiteflies, borers	Low vigor, poor flowering, weak tillering, aphids (repelled by strong odor)
Application Timing	During pest activity	Vegetative to reproductive stages
Dosage per Hectare	1–1.5 L	1–2 L
Toxicity Classification	Green Label (Slightly toxic)	Non-toxic
Key Benefits	Organic-approved, multiple pest targets	Improves crop vigor, natural growth promoter, organic aphid deterrence

Release of egg parasitoids *Trichogramma japonicum* for stem borer and *T.chilonis* for leaf folder management

Trichogramma chilonis and Trichogramma japonicum are egg parasitoids which effectively control egg mass of leaf roller, stem borer, skippers and cutworms. The parasitoids have to be released 15-30 days after transplantation or 25-30 days after sowing or immediately after noticing moth activity in the field. The release rate is 1 lakh parasitoids/ha of both sizes (5cc ha-1). The release has to be carried out at weekly intervals. The trichocard has to be cut into small pieces (minimum 10 pieces) and released in the main field, 6-8 releases is necessary to control the pest. Precaution : If larval attack is observed in the field, necessary organic/inorganic insecticides have to be used and a gap of 7 days has to be given before next release. The trichocards have to be placed during early morning or late evening hours and should not come in direct contact with sunlight.

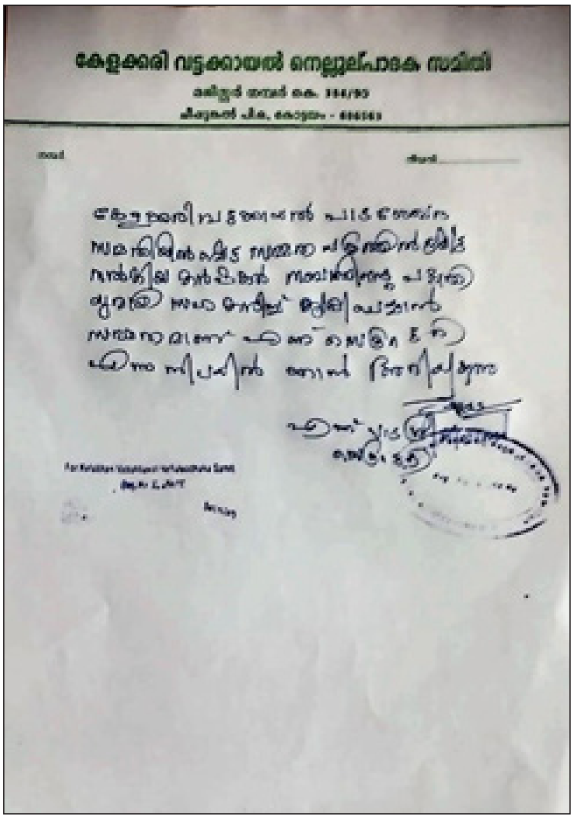
(Source: Package of Practices, KAU, 2016)

Lime/dolomite application recommendations

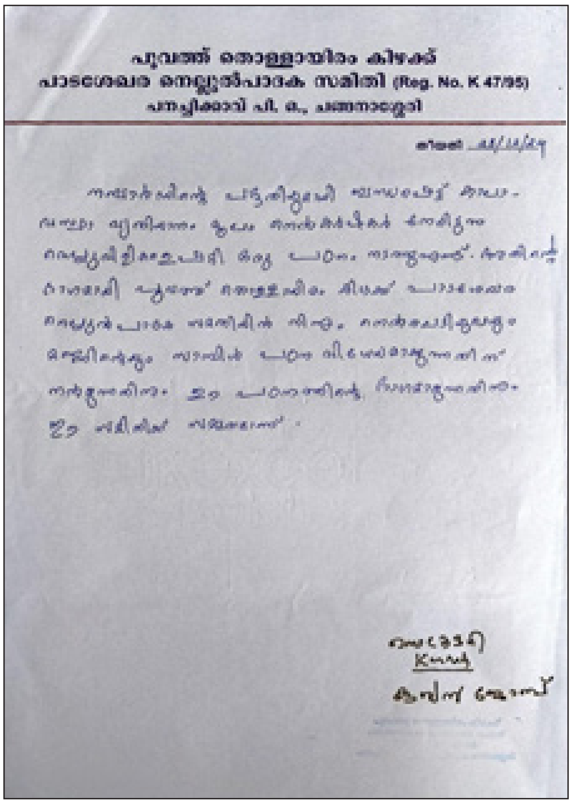
Addition of lime is absolutely necessary when the pH is lower than 5.5 and it is advisable when pH varies between 5.5 and 6.5. Apply lime @ 600 kg ha-1 in two split doses, the first dose of 350 kg ha-1 as basal dressing at the time of first ploughing and the second dose of 250 kg ha-1 as top dressing about one month after sowing/transplanting. A time lag of one week should be given between application of lime and fertilizers. For top dressing, lime may be applied one week prior to the application of fertilizers. In Kari soils of Kuttanad, apply Dolomite @ 450Kg/ha as two splits, half at the time of initial ploughing and half as top dressing one week prior to the application of fertilizers at the panicle initiation stage.

(Source: Package of Practices, KAU, 2016)

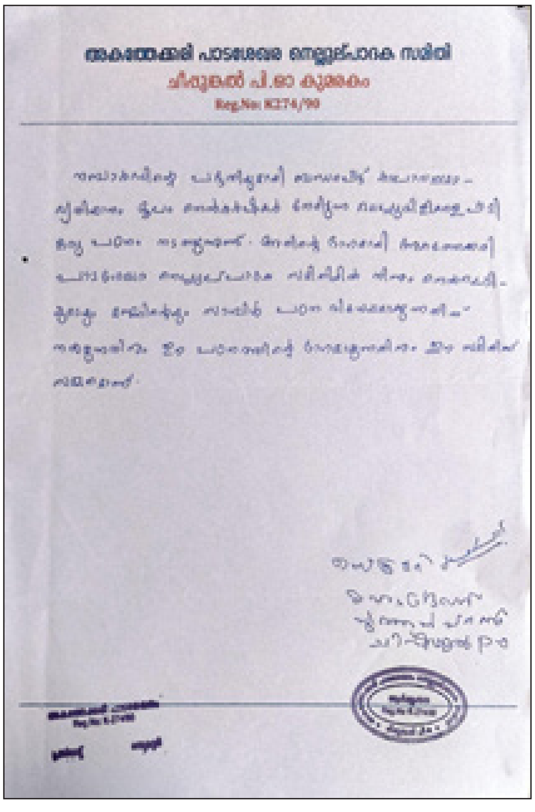
Appendix VI
Agreement Letters from Collaborating & Conventional Samithis



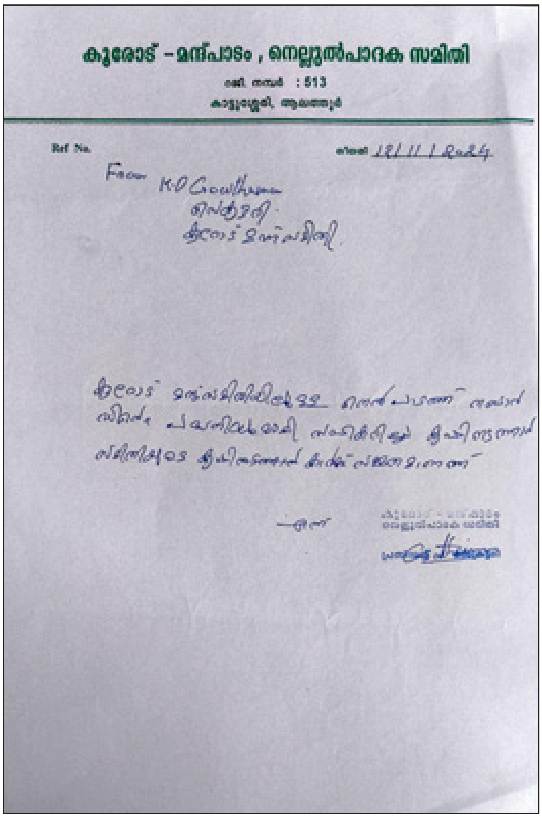
Kottayam Climate Resilient field



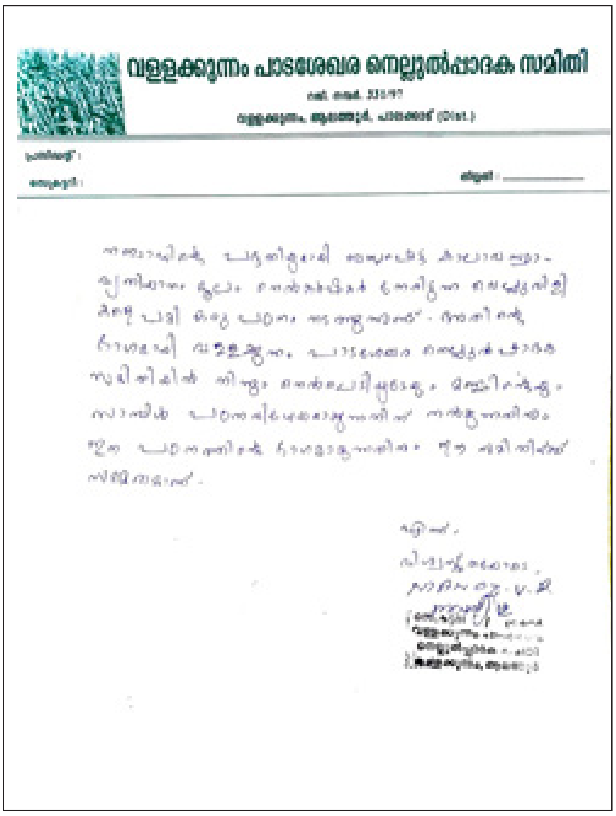
(Reg. No. K 47/95)



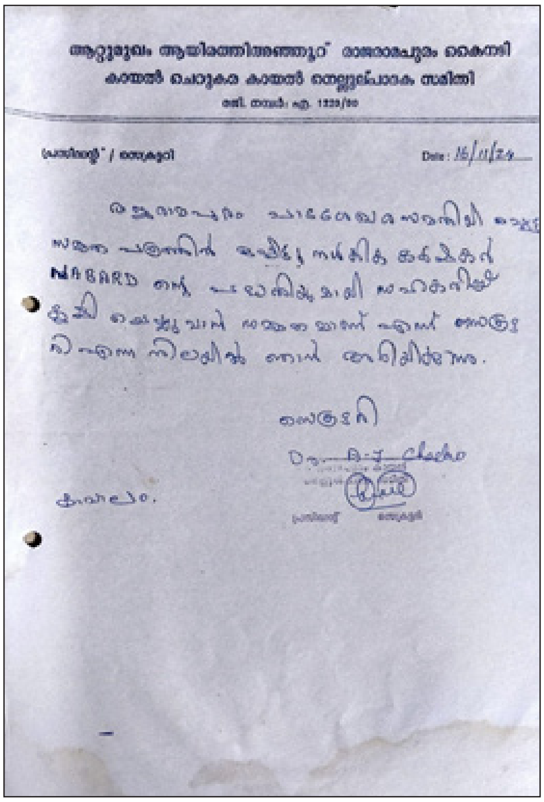
Kottayam Conventional fields



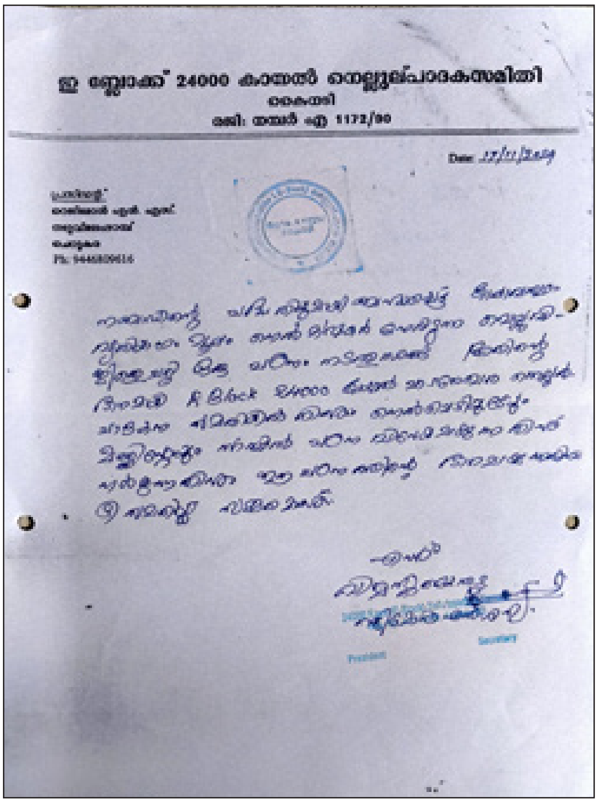
Palakkad Climate Resilient field



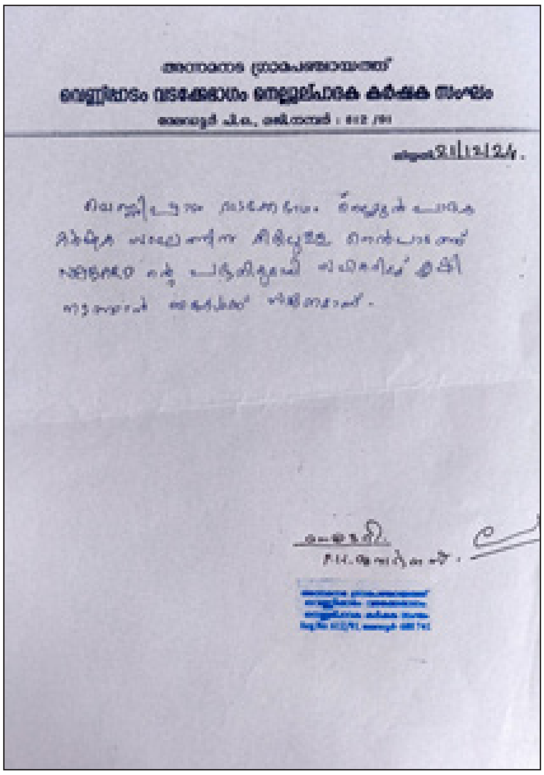
Palakkad Conventional field



Alappuzha Climate Resilient field

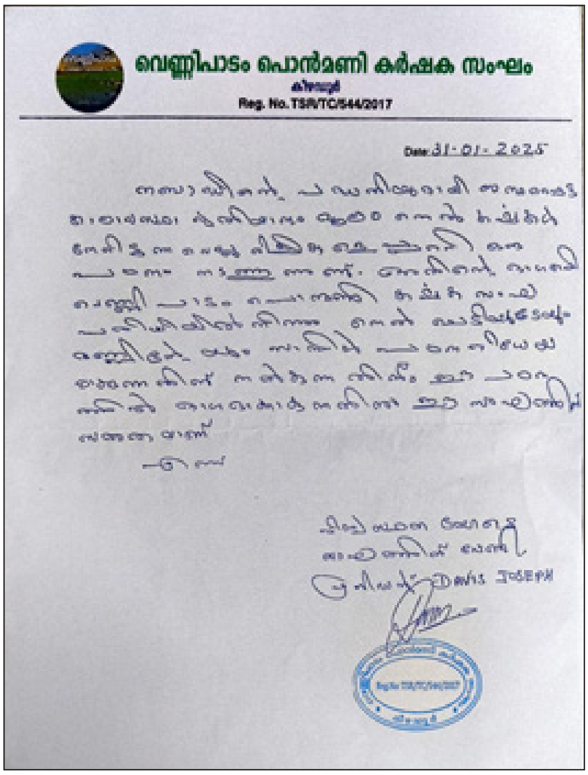


Alappuzha Conventional field



21/12/24

Climate Resilient field in Thrissur



വെണ്ണിപാടം പൊൻമണി കർഷക സംഘം

Reg. No. TSR/TC/544/2017

Date: 31-01-2025

DAVIS JOSEPH

Conventional field in Thrissur

Appendix VII
Details of Collaborating Samithis

a - KOTTAYAM
Samithi Adopting Climate Resilient Paddy Farming Protocol

Name of the samithi	: Kelakkari Vattakkayal Nellulpadaka Samithi
Krishibhavan/panchayath	: Arppookkara
Registration number	: K384/90
Name of the president	: P G Surendran
Name of the secretary	: V S Sreenivasan

Sl No:	Name	Phone Number	Land Holding (In Acre)	Survey Number
1	Kunjamma Joseph	9496156684	4.75	87/6-1
2	Renjamma	9496000918	2	65/2
3	Laiju T P	9447781302	3	72/4,3
4	Madanan K K	9947144088	0.5	62/2
5	Manoharan KV	9249593505	0.95	62/64
6	James Kuriakose	9633311141	4.95	87/6,6-12
7	Sudharmma Prasannan	9633032939	1.5	62/32.62 4/3
8	Mohandas K S	8089183428.	3.75	95/3 25,81/12
9	Nadesan	9526804710	4.5	196/6,88 /11
10	Rethiyamma E K	9633311141	0.5	83/3-84
11	Vijayan	9967508046	1.75	68/2-5 , 68/2-4
12	Prasad NK	9496000918	0.45	93/4-4
13	Prasannakumar	9744744322	0	88/20
14	Prasannan KS	9446554278	0.5	74/6 74/7
15	Prasannan T C	9746907913	0.5	60/86,66 /3,68/2-1
16	Prashobhant P	9744242762	4.5	93/3-9
17	Rajan Lv	9895506542	0.5	58/18
18	Rajeev P R	9645028121	0.5	84/1, 85/3
19	Ajin Jose	9142190247	1.7	93/317
20	Raji P. R	9446067215	4.95	88/17
21	Raju	9567151910	0.5	93/3-4
22	Raju S	9605044943	0.5	88/22
23	Ramakrishnan P K	9496000918	1.45	82/4, 82/6
24	Raghudas K R	9447114632	4.95	62/78, 62/68
25	Sabu Joseph	9946816102	4.95	87/6-15
26	Saji M T	9495107371	4.95	62/36
27	Sankan A C	9846475077	0.5	63/288
28	Sarala P M	9633311141	4	638/1.2
29	Sasi A V	9895700792	1	93/3-93/3-1

30	Satheesh A V	9446661393	1.25	85/1-4
31	Sathyan K S	9746951363	1	62/2
32	Shajimon K K	9746951363	0.5	93/3, 86/9
33	Shijjo K C	9495445843	1	62/81
34	Danai Roy	8111488632	0.92	61/3
35	Denny Joseph	9846184654	0.92	62/29
36	Soman T K	9387466450	0.5	95/19
37	Baiju M S	9947187245	0.75	62/25
38	Sajeev K S	9562285047	1	83/3,84
39	Sreenivasan V S	9633311141	2.5	95/7
40	Sudeer P N	9846407069	4.69	86/2,61/16
41	Sudharsanan A S	9846020973	3.5	88/4/6
42	Sukumaran	9567961016	0.5	83/12
43	Sukumaran Pappu	9567931016	3	86/3/95/16-1
44	Anadavally	8111186148	1.25	82/9/83/16
45	Sunil A S	9495525431	1	88/4
46	Sunil V K	9477544527	1	610/1
47	Vishnu Prakash	90486640474	1	69/1
48	Vinod M R	9288701368	2	623/37
49	Prasath	8111863148	2.75	68/6
50	Banjo Abraham	7034656770	4.75	68/9
51	Sivanandhan M	9447755758	.85	88/3-2
52	Manjusha C K	9496000918	4	88/12, 88/32

Conventional Samithi Selected For Comparative Study

Name of samithi : Akkathekari Padashekara Samithi
Registration number : K 274/90
Name of the krishibhavan/panchayath : Arppookkara
Name of president : Thankacahn K V
Name of secretary : Mahadevan P V
Total area : 67 acres
Total number of farmers : 60

Name of samithi : Poovathu 900 east Padashekara Samithi
Registration number : K 47/95
Name of the krishibhavan/panchayath : Paippad
Name of president : Sony
Name of secretary : Kurian job
Total area : 35 acres
Total number of farmers : 9

Alappuzha district
Samithi adopting climate resilient paddy farming protocol

Name of the samithi : Rajaramapuram Padashekhara Samithi
Registration number : A1220/90
Krishibhavan/panchayath : Kavalam
Name of the president : K P Shaji
Name of the secreatary : A J Chacko

SL NO:	Name	Phone number	Land holding (In Acre)	Survey number
1	Jojo Chacko	8606168472	5	171/1-2-1,172/2-3
2	Chacko Chacko	9747637233	1	128/31
3	Chacko Chacko	9747637233	2.8	140/3,140/3-1,128/5-1,137/4
4	Thomas Varghese	9961068684	5	96/2,26/1,26/1-2
5	Asha Rani Thomas	9656433802	3.25	150/1,162/1,162/2
6	Jyothy V Scaria	9495577457	2.35	173/3,137/5
7	Leelamma Ouseph	9495577457	3.5	78/2-2
8	John Joseph	9495577457	5	173
9	Ouseph John	9495577457	3.5	34/2,78/2,86,189/6
10	Vijayamma Y S	9656898230	2.08	29/9
11	Santhosh Kumar S	9061805700	2.3	170/1,170/1-1
12	Augustine E L	9061805700	0.88	128/28
13	Augustine E L	9061805700	3	96/1,95/5
14	Mukundakumar	9495477697	0.72	16/7,129/1
15	Devasia Joseph	9400647192	2.48	179/1-2-3-4
16	Rojo John	7306186462	2	170/3-2
17	Jaimol Devasia	7306186462	1.2	171/1-3
18	Unnikrishnan J P	8891783815	2.65	73/2-1
19	Mini D	9074183040	2.65	73/2
20	Mahesh V B	9744904014	0.98	44/4,44/5
21	M J Cheriyan	8921394306	1.11	147/1,45
22	Rani Cheriyan	9747489213	0.71	17/6-1,6,129/7,22
23	Rajesh P R	9037775846	2.27	53/1,53/1-1,53/2
24	Rajesh P R	9037775846	1.16	52/1
25	Sumy Surendran	9544088127	1	53/3
26	Sumy Surendran	9544088127	0.96	50/4
27	V N Chandran	9745516527	3	81/1
28	Mathew A C	7560867005	3.75	113/12,113/13,114/1-1
29	Annamma Mathew	7560867005	4.5	114/2,114/1

30	V P Rajappan	8547194281	1.63	107/2
31	Kanchana M J	8089174048	0.92	128/8
32	Mohanan G	8089174048	1	92/3
33	Rajalakshmi B L	2747760	1.08	45/5-2
34	Rajesh Kumar B	2747760	0.5	187/2-1
35	Bhaskarapanicker	2747760	3.2	187/2-2,187/2
36	Sreekumary Jayakumar	9497245699	1.74	115/2
37	Sreekumary Jayakumar	9497245699	2.28	115/1,115/3
38	Joseph Varghese	9645179705	1.09	119/1-1-1
39	Lissamma Joseph	8086931877	3.27	119/1-2
40	Sadanandan K	8547953481	1.97	108/1
41	Sarojini Raghavan	9847503062	1.34	124/2
42	K K Sukumaran	9496523821	4	85/5-1,85/3-1
43	Premji KP	9495145293	4	4/2,4/5
44	Sreelekshmi G P	9495145293	4.87	103/11,93/2,3,93/4
45	Sajinimol KS	9495145293	4.06	45/1,94/2-1
46	M J Joseph	9496272748	4	147/1-1,122/1128/30
47	Somi Joseph	8921202433	2.66	104/1-1,104/1-2
48	Joseph Varghese	8921202433	0.59	104/3-1
49	Mariyamma Joseph	8921202433	4.18	78/2-3,104/2,104/3
50	Ammini	9446454202	2.42	169/4
51	Mohini Vijayan	9072368118	0.75	133/6
52	Shibu M	7736127857	1.46	133/6-1,16/8,129/2
53	Shailamma K P	9961576016	0.9	128/36
54	Krishnankutty M N	9446447748	2.33	140/8,131/4,132/5
55	Gangadharan K P	9605103647	1.03	46/1
56	Mariamma Joseph	7559802942	1.5	128/1-3,128/4
57	Gireesh Kumar P B	8547698063	3.91	15/7,16/1,131/1,134/6,15/9,134/4,134/6
58	Ajeesh K A	8089107080	3.68	51/1
59	Thomas Joseph	9495832949	0.83	130/2
60	Jomon Devasia	9037411061	1.46	32/2-1
61	Siji Joseph	9037411061	3.24	14,19/2-1
62	Chacko Thomas	9645422386	2	120/2-1
63	Shibu N V	9400554145	0.75	165/3
64	Gracamma Joseph	8891845896	2.43	36/1,36/1-2
65	Chachappan G	9496378176	1.4	176/14,176/2
66	Sarika Shibu	8281681733	1.5	112/1
67	Shibumon Joseph	9495087034	1.28	124/3

68	Suseelan M S	9400663207	1	49/4
69	Suseelan M S	9400663207	1.1	49/3
70	Suneeth Chacko	9961923394	1	34/3-2
71	Suneeth Chacko	9961923394	1.4	34/3
72	Jainkumar P K	6366555435	1.86	201/10,180/1-1
73	Shaphy	9496691185	2	109/3-1,109/3
74	Abhilash P K	9747358546	0.8	128/27-2-1
75	Sibichan P	9497761151	4.9	13/1-2,32/2-3
76	George Thomas	9495838177	4.37	9/1
77	Harikumar H H	9495571167	5	80/7-2
78	Sreedevi S H	9447531412	1	80/7
79	P K Raju	8606567456	1.97	151/2
80	Rakesh C Mohan	9495212135	0.94	38/3
81	K S Chandramohanan	9495212135	2.8	37/2
82	Sanalkumar K C	9495212135	1.15	38/5
83	George Sebastian	9747828301	3.79	153/1
84	Jijikumar G	9747773131	2	52/4
85	Thankappan M N	8086649514	2.75	46/6-313/2
86	Kunjumon P S	9847316256	5	80/9-2
87	Thresiamma Jose	9400747525	4.7	14/1-1
88	E T Josekutty	9400747525	3	13/1-1
89	Thankachi Mathew	9645855391	3.26	3/5,3/3,3/4,4/1,3/9,4/3
90	Tony Mathews	9645855391	4	3/5,3/3,3/4,4/1
91	Mathew Antony	9645855391	4	4/1,3/9,4/3
92	Ansamma Thomas	9495162683	1.62	27/1-2
93	Ratnakaran V	8606017651	3.11	59/2,80/2,80/1-5
94	Kunjamma	9495649733	3.6	137/2,92/2-4,92/2-2
95	Majeeshkumar A P	9495649733	4	30/3
96	Manojkumar A P	9061626767	2.9	11/2,23/2
97	Rejitha K K	9747594259	4.5	11/2,23/2
98	Viji K	9048551856	1.8	131/2,128/3-2-1
99	Subash K S	8156921732	5	8/1-3,8/1-4

Conventional samithi selected for comparative study

Name of the samithi	: 24000 kayal, e block
Registration number	: 1172
Panchayath/krishibhavan	: Kavalam
Name of the president	: Rajimon
Name of the secretary	: Anil Kumar R
Total area	: 2367 acre
Total number of farmers	: 1132

Palakkad district
Samithi adopting climate resilient paddy farming protocol

Name of the samithi	: Kurodmannu paddy farming society
Registration number	: CA/513/01
Panchayath/krishi bhavan	: Alathur
Name of the president	: Ashish
Name of the secreatary	: Gowthaman

Sl No.	Name	Phone number	Land holding (in acre)
1	Appu M	9745885552	0.45
2	Aravindhakshan VM	9446818793	1.08
3	Asish	9846048800	1.38
4	Babu V	8129640453	0.62
5	Balan C	9446876299	0.66
6	Bindhu S	9497750376	0.68
7	Chandrika C	9495056106	0.14
8	Chella	9544296508	0.76
9	Devi K	9447922262	1.7
10	Gopika S	9847391231	0.43
11	Gowthaman KD	9745644213	3.15
12	Ibrahim A	9645627359	1.1
13	K Kalyani	8089708557	0.54
14	KL Santha	9745280435	0.78
15	Kamakshikutty V	9446104799	1
16	Krishnan A	9447889316	1.37
17	Krishnan A	9447889316	1.12
18	Krishnankutty R	9744081441	1.85
19	Kumari T	9496193569	0.99
20	Meenakshi	8129640453	0.3
21	Mohandas	8086497370	0.62
22	Mujeeb Rahiman	9447240065	0.66
23	Muralidas	9495036557	0.72

24	Muthu	8606778779	0.35
25	N Chandran	9745280435	1.2
26	Nagoor Meeran	9037413765	0.52
27	Prabhavathy P	9567819106	0.42
28	Purushothaman K	9497750376	2.57
29	Rajan C	8086433005	0.36
30	Ramachandran PR	9447608228	0.62
31	Ramakrishnan K	9388901043	0.75
32	Ramesh R	9447922262	1.11
33	Rasiya	9526573180	0.67
34	Ravi	9847391213	0.9
35	Rugmini	9400823284	0.38
36	Sajeesh Kumar	9544222789	0.44
37	Santhakumari	9544918308	0.73
38	Santhi	9745112323	1.06
39	Santhosh Kumar	9544222789	0.83
40	Satheesan	9142230319	0.44
41	Satheesan	9142230319	1.74
42	Satheesh kumar	9544222789	0.46
43	Sekharan	9448354489	0.53
44	Sivadas A	9447375345	0.30
45	Sivadas PR	9447251219	0.31
46	Sivadas PR	9447251219	1.65
47	Thankamani Chellappan	7559847613	0.60
48	Unnikuttan C	9496193569	0.56
49	Usha Parvathy	9400633644	0.5
50	VM Aravindhakshan	9446818793	0.9
51	Valsala C	7736744586	2.5
52	Vasu K	9562194459	0.3
53	Vasudevan A	9544918308	1.7
54	Velayudhan	9961982761	0.45
55	Vinod R	9846622038	1.73
56	Vrindha V	9562195501	1.1
57	Yashoda PK	9544222789	1.83

Conventional Samithi Selected For Comparative Study

Name of the Samithi : Vallakkunnam Padashekhara Samithi
Registration number : 331/97
Panchayath/krishi bhavan : Alathur
Name of the president : Manoj
Name of the secreatary : Raghu
Total area : 91.7 acre
Total number of farmers : 75

Thrissur District
Samithi Adopting Climate Resilient Paddy Farming Protocol|

Name of the Samithi : Vennipadam North Padashekhara Samithi
Registration number : 612/91
Panchayath/Krishi Bhavan : Annamanada
Name of the President : K K Rajan
Name of the Secreatary : P K Janardanan

Sl no	Name	Phone number	Land holdings (in acre)
1	Baiju v v	9605872868	5
2	Balakrishnan k k	9048743310	2
3	Janardanan	9947694756	2
4	Joby t o	9846862277	1
5	Johnson	9497782023	2
6	Jose k k	9447775215	3
7	Kishor kumar k k	9961069097	9.81
8	Lakshmikutty	9048743310	2
9	Maries shaji	9400937825	4
10	Mini kc	9061451997	3.14
11	Miss jyothi k s	8086633362	4.92
12	Mohanan k k	9747057161	6
13	Mohanan p k	9496123014	0.31
14	Rani baiju	9605872868	5
15	Sadanandan k m	9605367437	5
16	Sivan	9544934494	0.77
17	Soumya k krishnan	7560965188	4.92
18	Subran v k	9446621606	1
19	Sunilan k s	9895849237	4

20	Umesh krishnan m	9447350678	4.92
21	Unni k d	8547181090	3
22	Venu	9495566561	5
23	Vineesh c t	9495041743	2
24	Vineetha thomas	9497626819	0.85

Conventional Samithi Selected For Comparative Study

Name of Samithi : Vennipadam Ponmani Karshaka Sangham
Registration number : TSR/TC/544/2017
Panchayath/Krishibhavan : Annamanada
Name of President : Davis Joseph
Name of the Secreatary : Rijoy C R
Total area : 70 Acres
Total number of farmers : 34

Appendix VIII
Questionnaire for Selected Farmers

TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES(TIES)
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Study on Impact of Climate Change on Rice Cultivation in Kerala and Development of Mitigation and Adaptation Strategies

Questionnaire for Selected Farmers on Previous Puncha Crop (2023/1199)

Farmer Information

1. Name: ________________________________

2. Farm Location: ____________________________

3. Farm Size (acres) Total ________Own _________Lease ________Fallow _________

4. Contact Information: ______________________________

5. Name of Samithi: _________________________________

6. Panchayath_________________________________

Rice Crop Information

7. Variety of Rice Grown Last Year:

☐Uma
☐Jyothi
☐Manuratna
☐Pournami

8. Quantity of seed used per acre: _______________

9. Method of sowing:

☐Broadcasting
☐Transplanting

10. Total Yield (tons): ______________

11. Yield per Acre (tons): ______________

12. Days to Maturity: ______________

13. Date of Sowing: ______________

14. Date of Harvesting: ______________

15. Weed control methods followed:

☐Herbicide use
☐Manual weeding
☐Others

16. Fertilizer application:

Chemical fertilizers: ___________% Organic fertilizers: ___________%

Number of rounds of fertilizer application:

Cost of cultivation

17. Total Production Cost

Type of cost	Amount
Land preparation (Ploughing, leveling, and other soil preparation costs)	
Seed	
Fertilizer	
Pesticide	
Herbicide	
Irrigation (Costs related to irrigation systems like flooding)	
Machineries	
Labour	
Post-harvest	
Transportation	
Nerma (Samithi fee)	
Other	
Total	

18. Subsidy Received:

SL No	Kind of subsidy	Details
1	Pump/motor subsidy	
2	Seed/lime/fertilizer subsidy	
3	Incentive bonus	
4	Other	

19. Insurance claim. If yes;

Type of insurance	Coverage

20. Climate related incidents and impacts

- Untimely rainfall:____________________________
- Irregular rainfall:_____________________________
- Cloudy/humid atmosphere:_________________________________
- Flood/inundation of the field:______________________________
- High ambient temperature:_____________________________
- Other:______________________________

Marketing and Sales

21. Marketing Channels Used:

☐Direct to Consumer
☐Local Markets
☐Supplyco
☐Export
☐Other: _____________

22. What are the challenges in marketing?

____

23. Total Revenue: _____________

24. Deduction of price: _____________%

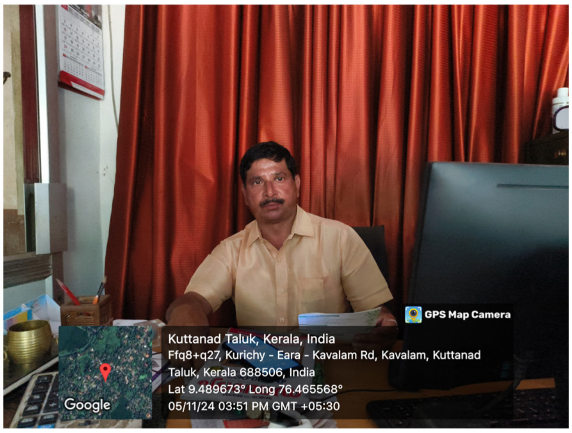
Declaration

ഈ സമഗ്ര കൃഷി പദ്ധതിയുമായി സഹകരിക്കാൻ ഞാൻ തയ്യാറാണ്

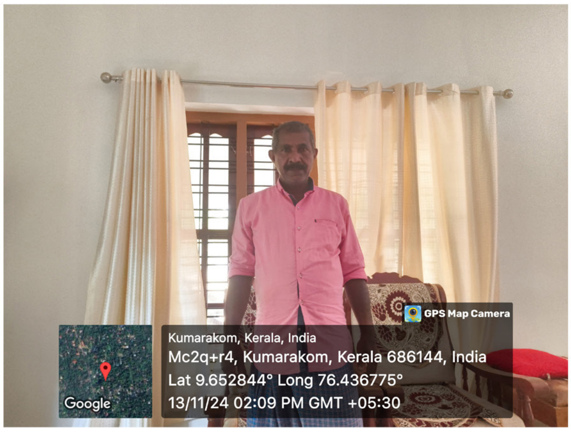
തിയ്യതി **ഒപ്പ്**

Appendix IX
Collaborated farmers

a - Alappuzha and Kottayam



a - Alappuzha and Kottayam



b - Palakkad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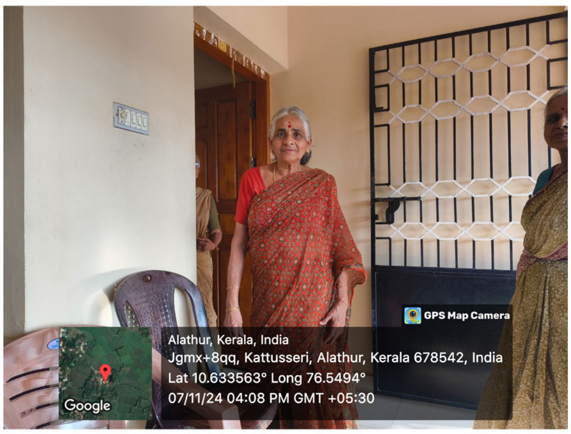
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b - Palakkad


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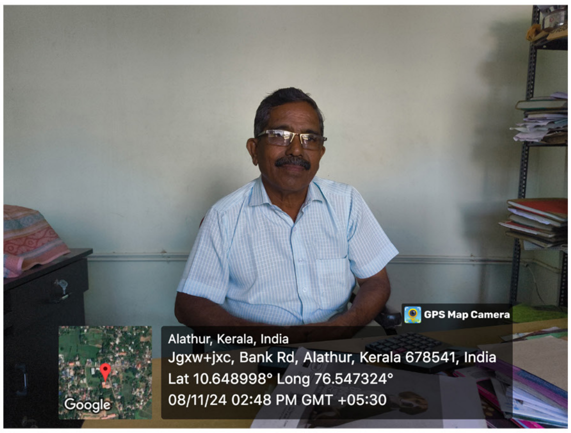
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b - Palakkad


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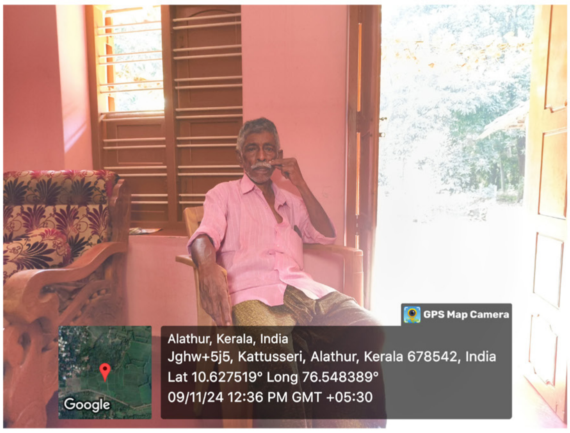
b - Palakkad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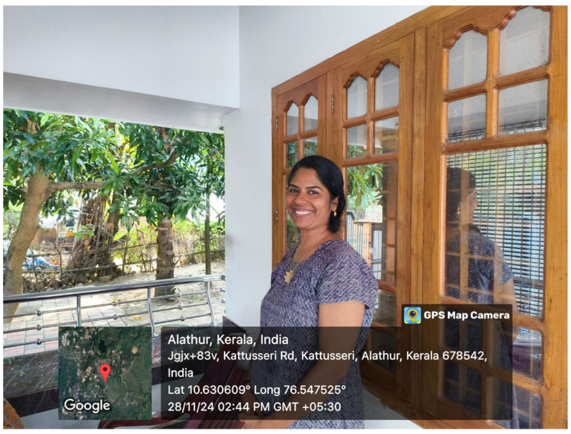
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b - Palakkad


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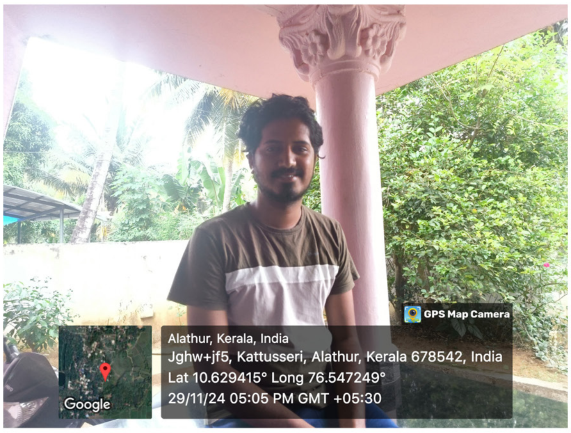
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c - Thrissur


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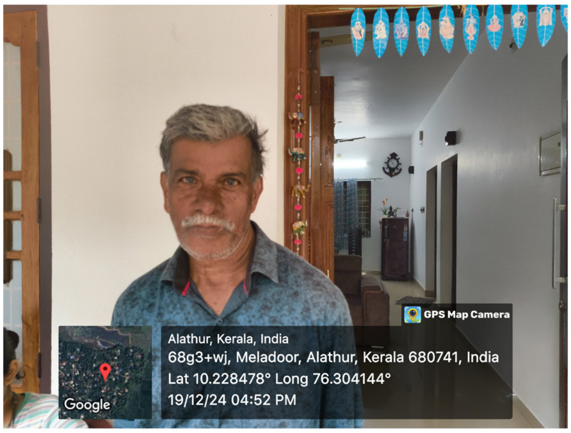
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c - Thrissur


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Appendix X
List of Collaborated Farmers

a - Alappuzha

SL No.	Name	Address	Phone	Area (Acre)
1	Vijaykumar	Ezhupathil Chira Kavalam P O Alappuzha	9400747574	17
2	Majesh Kumar	Aril, Kavalam P.O	9495649733	7.5
3	Ratheesh	Rajesh Bhavan,Kavalam North P O,Kava-lam,Alappuzha	9747480797	5
4	Shaji	Aiswaria,Kavalam P.O, Alappuzha	9446194022	7.5
5	Biju Mon Varghese	Kaniyamparambil, Kavalam North P O	9946645990	13
6	Joby	Aril Puthenkalam Kurisumoodu P O Kottayam	8848348176	14
7	Joseph AJ	Attichira, Kavalam P.O, Alappuzha	9447975508	10.5
8	Biju Mon PJ	Thattunkalparambil Kainady P O Kainady	9496425002	15
9	AJ Chacko	Edayady House, Moncompu Po, Allappuzha	9447473432	25
			Total area	114.5

b - Palakkad

Sl No.	Name	Address	Phone	Area (Acre)
1	Gowthaman	Kizhakkumpuram Kattussery Alathur	9745644213	4
2	Valsala	Neelampottakalam, Kattussery, Alathur	7736744586	3
3	Ashish	Neelampotta-kalam,Kakkamoochikkad,Kat-tussery	9846048800	2.5
4	Unnikkuttan	Chathamkulam House Kattussery Alathur	9496193569	1.85
5	Sudevan	Kizhakkumpuram Kattussery Po Alathur	9142230319	2.5
6	Ravi	Koorode Kattussery Po Alathur	9745644213	1.5
7	Muthu	Punnamkulam, Kakkamoochikkad, Kattussery	8606778779	0.5
8	Krishnan Kutty	Kumbalakode House Alathur	9744081441	1.85
9	Sajeesh Kumar	Punnamkulam House Kattussery Alathur	9544222789	1.5
10	Aravindahshan	Vellat Veedu Kattussery Po	9446818793	2
11	Kamakshikkuty	Mele Vellatt House Kattussery	9446104799	1
12	PK Mohanan	Navaneetham Plakkaparambu Kattussery Po	9447325878	21.86
13	Gopinath	Kizhakke Veedu Kattussry	8606932765	0.6
14	P Krishnan Kutty	Punnankulam House Kattussery	9447889316	3
15	Mujeeb Rahman	Marhaba Manzil Punnamkulam Kattussery	9447240065	0.65
16	Chella	Punnamkulam House Kattussery Alathur Pa-lakkad	9544296508	0.76
17	K Kalyani	Kumbalakode House Alathur	8089708557	0.55
18	Balan C	Nani Nivas Kandanthodi Bank Road Alathur Po	9446876299	0.66
19	James	Vayalappalliyil House Kattussery	9048030821	0.8
20	Sundaran	Kunnath Veedu, Kakkamoochikkad,Kattussery	8156829122	5
21	Chandran Narayanan	Vadotta House Nelliyamkunnam Alathur Po	9745280435	2
22	Usha Parvathi	Mele Vellatt House Kattussery	9400633644	0.5
23	K Vasu	Punnamkulam, Kattussery	9562194459	0.3

24	Vasudevan	Nelampottakalam Kattussery Post,	9544918308	3
25	Devi	Punnamkulam House Kattussery Alathur Pa-lakkad	9447922262	3
26	Subaida	Punnamkulam House, Kattussery	9037413765	0.5
27	Prabhavathi	Valiyavellatt House Kattussery	9567819106	0.42
28	Rasiya	Kakkamuchikkad Kattussery	9526573180	0.67
29	Sivadas A	Poolakkal House ,Nariyamparambu,Kattussery	9447375345	0.3
30	Rajan	Chathamkulam House Kattussery Alathur	8086433005	0.39
31	Appu	Koramkulam ,Kattussery	9745885552	0.5
32	Velayudhan	Punnamkulam Kattussery Alathur	9961982761	0.5
33	Purushothaman	Kattussery, Alathur	9497750376	3
34	Rugmini	Punnamkulam House Kattussery	9400823284	0.4
35	Thankamani chellapan	Punnamkulam Kattussery	7559847613	0.6
36	Vinod	Neelampottakalam Kattussery Po Alathur	9846622038	2
37	Muralidharan	Plakkaparambu Kattussery Alathur	9745456683	3.5
38	Deepa Rajesh	Krishnadeepam Tharayil Chakkingal House Kattussery	9495056106	0.35
39	Kumaran	Plakkaparambu Kattussery Alathur	9744366448	3.7
40	Ponnukuttan	Plakkaparambu Kattussery Alathur	9744391252	1.2
			Total area	82.91

c - Thrissur

SL No.	Name	Address	Phone	Area (Acre)
1	Rajan	KAIPPILLYPARAMBIL HOUSE MELADOOR P O KEEZHADOOR	9961069097	12
2	Venu	KAYAKODAN MELADOOR P O ALATHUR	9495566561	5
3	Unni KD	KAYAKODAN HOUSE MELADOOR P O MELA-DOOR	8547181090	3
4	Mini KC	KAIPPILLY MADOM,P O MELADOOR,VIA AN-NAMANADA,THRISS	9061451997	3.2
5	Mohanan	KAIPPILLYPARAMBIL HOUSE, KEEZHADOOR, MELADOOR P O	9747057161	6
6	Subran	VENMANAPARAMBIL HOUSE MELADOOR P O KEEZHADOOR	9446621606	1.18
7	Shaji CP	CHAKKALAKKAL HOUSE	9400937825	4
8	Johnson	ARAKKAL HOUSE MELADOOR P O MELA-DOOR	9497782023	2
9	Sunilan	AYAKKODAN HOUSE MELADOOR P O	9895849237	4
10	Vineesh	CHALANA, CHALAKKULAM, KOTTAPPURAM P.O, KODUNGALLUR	9495041743	2
11	Janardhanan	PONNETHUPARAMBIL HOUSE MELADOOR P O MELADOOR	9947694756	2
12	Jose	KATTOOKKARAN (H), MELADOOR, NEAR CHURCH. P.O.ALATH	9447775215	3
13	Sreekrishna Kumar	VITHAYATHIL HOUSE MELADOOR P O	9605872868	1
14	Balakrishnan KK	KARYADAN HOUSE MELADOOR P O	9048743310	25
15	Shivan AP	ADIMUTTATHARAYIL HOUSE, EDAYATTOOR , ANNAMANADA P	9544934494	0.7

16	Joby TO	THAYYIL MELADOOR P O KEEZHADOOR	9846862277	0.96
17	Shaju KD	PARAKKAL HOUSE MELADOOR P O MELA-DOOR	9400012673	6.5
			Total area	81.54

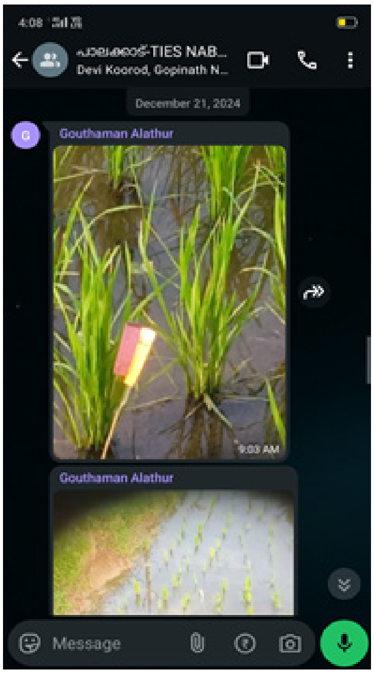
d - Kottayam

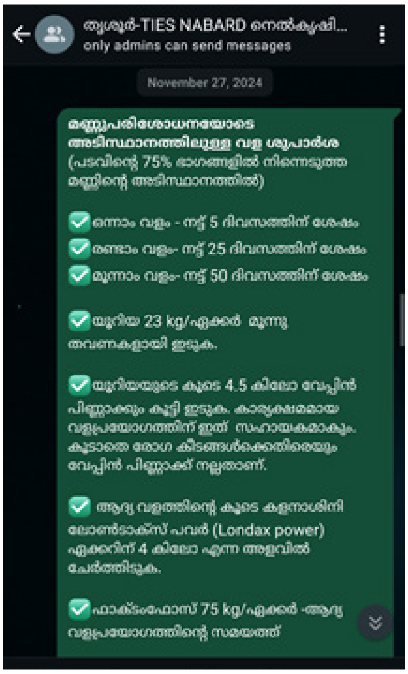
SL No.	Name	Address	Phone	Area (Acre)
1.	Jomon	PUTHENKALAM ,CHEEPUNKAL	9035544414	24
2.	Sabumon	PUTHENKALAM ,CHEEPUNKAL	9037487451	8
3.	Thomaskutty	PUTHENKALAM	9447850605	50
			Total area	82

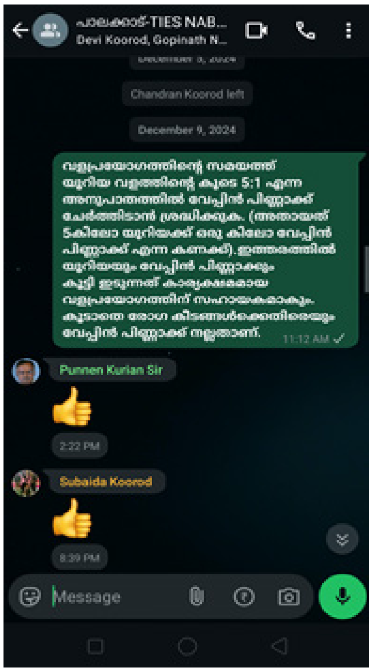
Note: One of the collaborating farmers, Mr. Thomaskutty has 50 acre fields in Changanassery, belonging to two Padashekhara samithi, Kapponappuram & Ulakathanam Padashekhara Samithi, Changanssery.

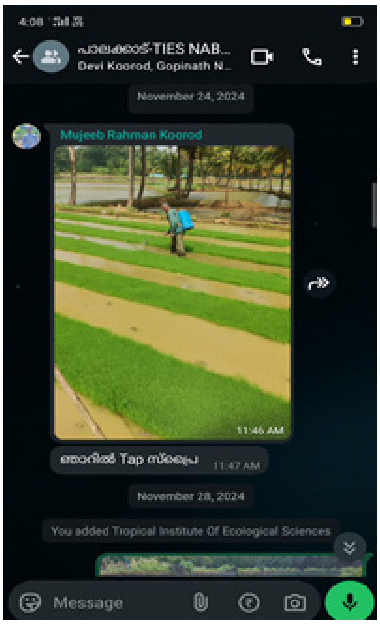
Appendix XI

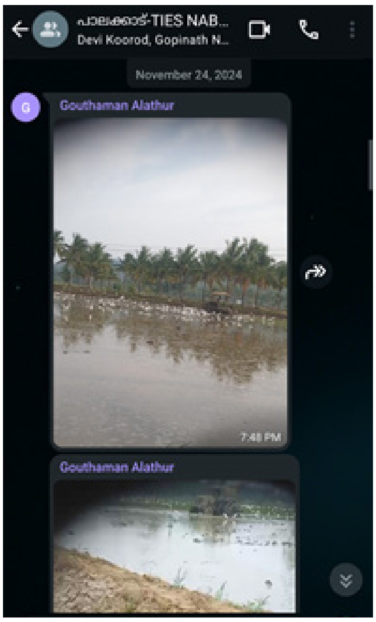
Whatsapp based Advisory Group

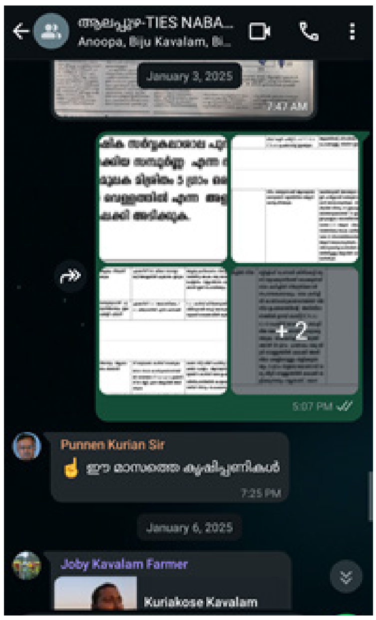


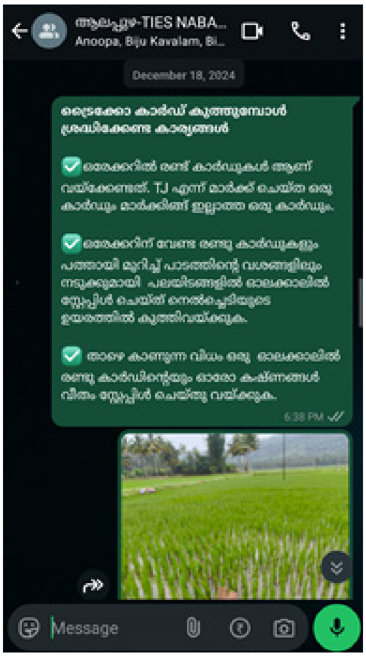


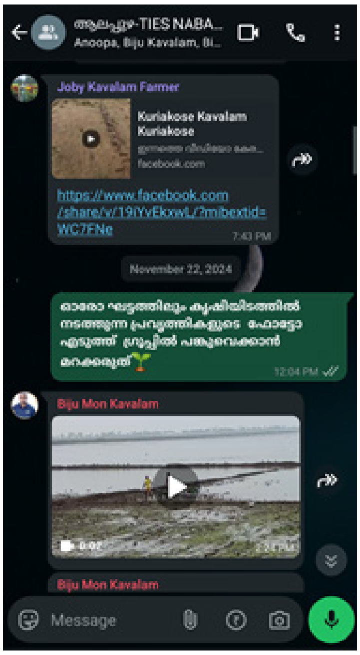


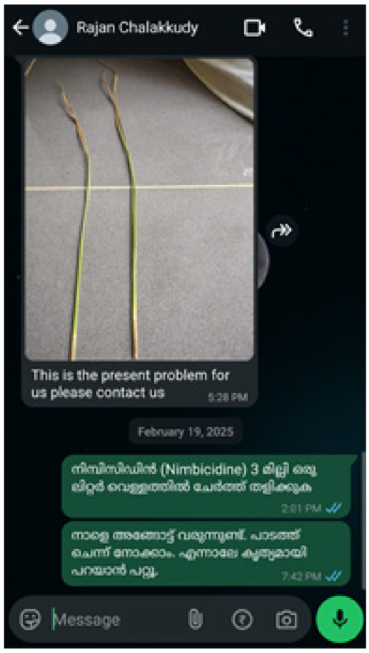












Appendix XII

Weedicides and Pesticides Used by Farmers in Rice Cultivation

Name of weedicide/ pesticide	Dosage	Chemical composition	Toxicity label
2,4 D	500ml/acre	2,4-dichlorophenoxyacetic acid	Yellow
Vivaya	800-1000 ml/acre	Penoxsulam and Cyhalofop-Butyl	Blue
Affinity	20g/acre	Carfentrazone-ethyl	Green
Vayego	100-120 ml/acre	Tetraniliprole	Blue
Saathi	40-60 g/acre	Pyrazosulfuron ethyl	Blue
Council active	90g/acre	Triafamone and ethoxysulfuron	Blue
Londax power	10 kg/ha	Bensulfuron methyl+ Pretilachlor 0.6+6 G	Blue
Nominee gold	250-300 ml/ha	Bispyribac sodium	Blue
Finish	30g/acre	Chlorantraniliprole	Green
Rammix	8g/acre	Methyl + Chlorimuron Ethyl	Blue
Basta	2.5-3.3 litres/ha	Glufosinate ammonium	Blue
Clear	2.5 - 3 litres/ha	Paraquat dichloride	Yellow
Roundup	800-1600ml/acre	Glyphosate	Blue
Taarak	100-120 ml/acre	Bispyribac sodium	Blue
Oryzostar	80-100ml	Bispyribac sodium	Blue
Loyant	470 ml/acre	Florpyrauxifen-benzyl	Green

Goal	640 ml/ha	Oxyfluorfen	Blue
Propanil	1000-1500 g/acre	Propanil	Yellow
Almix	8 g/acre	Metsulfuron ethyl + Chlorimuron	Blue
Nativo	120g/acre	Tebuconazole and trifloxystrobin	Blue
Clincher	800 ml/ ha	Cyhalofop butyl	Green
Gramaxone	0.5-1 l/acre	Paraquat dichloride	Yellow
Origin	400-500 ml/ ha	Flubendiamide 3.5% + Hexacon-azole5%	Blue
Tagmycin	100–200 g	Streptomycin Sulphate	Green
Kriman	1-1.5 g/ 1 L of water	Kresoxim methyl 18% + Mancozeb 54% WP	Blue
Kakuna	200-250 ml/acre	Novaluron 5.25% + Emamectin Benzo-ate 0.9% SC	Blue
Nimbicidine	1-1.5L/ha	Azadirachtin 0.03%	Green
Refit	400-600ml/acre	Pretilachlor	Blue
Basco	80ml – 120ml per acre	Bispyribic sodium 10%	Blue
Kargil	50-80 ml/ acre.	Imidachloprid	Yellow
Coragen	150 ml/ha	Chlorantraniliprole 18.5 SC	Green
Karate	120 ml/acre	Lambda cyhalothrin 5 EC	Yellow
Gambhir	400ml/acre	Chlorpyriphos + Cypermethrin	Yellow
Fiproplus	400-600 ml/acre	Fipronil	Yellow
Fame	20 ml/acre	Flubendiamide	Green
Takumi	50gm/acre	Flubendiamide	Green
Ekalux	400ml/acre	Quinalphos, dimethyl benzene	Yellow
Actara	100-200 gram/ha	Thiamethoxam 25 WG	Blue
Chlorpyrifos	5 ml/ 1 L of water	Chlorpyrifos	Yellow
Gunther	600ml/acre	Novaluron 0.9% SC Emamectin Ben-zoate	Blue
Minori	125g/ha	Flubendiamide	Green
Champion	100 ml/Acre.	Spinetoram	Blue
Shinwa	160 ml / Acre	Fluxametamide 10% EC	Blue
Cymbush	200-500m	Cypermethrin	Yellow
Ferterra	10 kg/ha	Chlorantraniliprole	Green
Adora	100-120 ml/acre	Bispyribac sodium 10 SC	Blue
Instant	100 ml/acre	Lambda cyhalothrin 5 EC	Blue
Contaf	200 ml/acre	Hexaconazole	Blue
Asataf	250 ml/acre	Acephate 75% SP	Blue
Reeva	500 ml/ha	Lambda cyhalothrin 2.5 EC	Yellow

Barroz	3 kg/acre	Cartap Hydrochloride 7.5% w/w + Emamectin benzoate 0.25% w/w GR	Blue
Coreon	800-1000 ml/acre	Penoxsulam 0.97%+ Butachlor 38.8% SE	Blue
Jump	50ml/acre	Fipronil 80WG	Yellow
Fenval	50-200 ml/acre	Fenvalerate 20% EC	Yellow
Duton	1-1.5lit/acre	Penoxsulam 21.7% SC	Green

Appendix XIII

Post Harvest Survey Questionnaire

TROPICAL INSTITUTE OF ECOLOGICAL SCIENCES (TIES)
www.ties.org.in

Study on Impact of Climate Change on Rice Cultivation in Kerala and Development of Mitigation and Adaptation Strategies

Questionnaire for Selected Farmers on Puncha Crop (24-25)

Name: ______________________________

Contact number: __________________________

1. Cost of Cultivation

Type of cost	Description	Amount	Remarks
Land preparation	Tractor/tiller hire		
	Manual labour		
	Time required (hrs)		
Lime and liming	Quantity used (kg)		
	Subsidy received		
	Additional cost borne		
Seed	Subsidy received		
	Additional cost borne		
Sowing	Manual/mechanical		
	Cost of sowing		
	Resowing cost (if applicable)		

Fertilizer & labour	Fertilizer cost		
	Cost of micronutrient mix		
	Cost of labour (owned/hired/ contract)		
	Transportation cost		
	Drone application cost (if used)		
Plant protection	Pesticides applied and dose		
	Pesticide cost		
	Cost of labour (owned/hired/ contract)		
	Cost of trichocard		
Weed management	Herbicide applied and cost		
	Herbicide cost		
	Cost of labour (owned/hired/ contract)		
	Manual weeding cost		
	Mechanical weeding cost (weed wiper)		
Household labour	No. of family members involved		
	Total person days		
	Estimated wage values		
Irrigation	Public system (canal/pump)- availability and cost		
	Private (motor/tubewell)		
	Pump capacity (HP)		
Harvesting	Harvester rent per hour		
	Manual labour cost		
	Tractor cost		
	Details about harvester contract		
Post harvest	Bagging		
	Transportation		
	Loading /unloading		
Samithi fee (Nerma)			
Other costs	Specify (eg: land lease, storage)		

→ Total Cost of Cultivation per acre (2024-25): ₹ ________________________|

→ Total Cost of Cultivation per acre (2023-24): ₹ ________________________

→ Total Revenue (2023-24): ₹ ________________________

2. Subsidies Received

SL No	Type of subsidy	Beneficiary (farmer/ samithi)	Source (Krishi Bhavan/ other)
1	Seed subsidy		
2	Lime/fertiliser subsidy		
3	Pump/motor subsidy		
4	Ploughing subsidy		
5	Other (specify)		

3. Insurance Details

SL No.	Insurance Type	Coverage & Premium
1	State Crop Insurance Scheme	
2	Restructured Weather Based Crop Insurance Scheme	

4. Harvest Details

SL No.	Details	Amount
1	Total grain yield (Q)	
2	Straw yield (No. of rolls)	
3	Yield per acre (Q)	
4	Total revenue (₹)	
5	Date of harvest	
6	Deduction (%)	

5. Climate Related Incidents and Impacts

SL No.	Incident Type	Occurred (Y/N)	Details/Impacts (eg; area affected, yield loss)
1	Untimely rainfall		
2	Irregular rainfall		
3	Cloudy / humid atmo-sphere		
4	Field flooding/ inunda-tion		
5	High ambient tempera-ture		
6	Wind damage		
7	Pest/disease outbreak linked to climate change		
8	Other (specify)		`
9.			

Appendix XIV
Post harvest pictures

a - Alappuzha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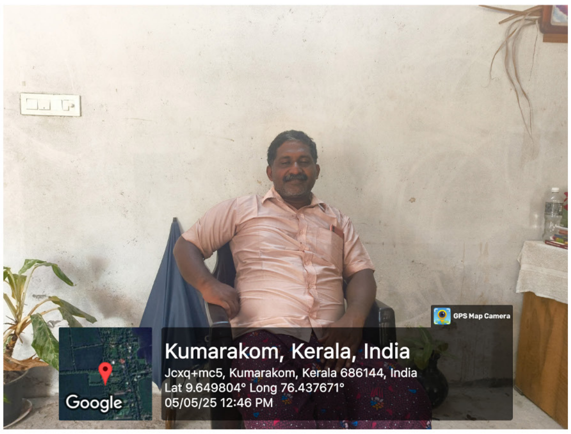
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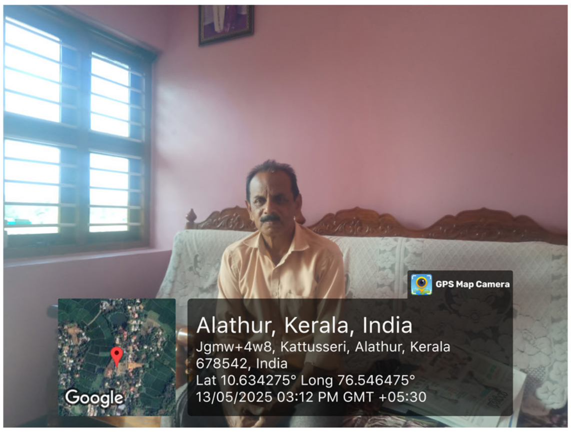
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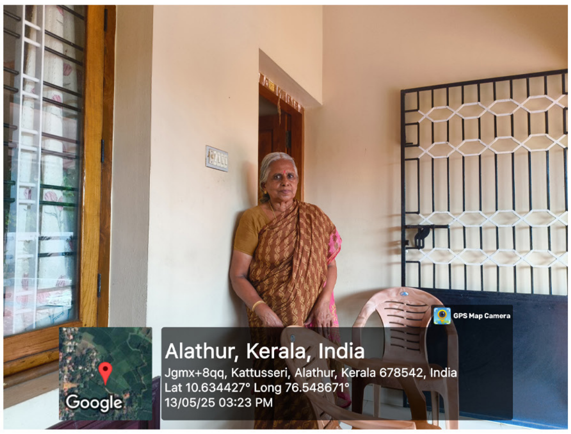
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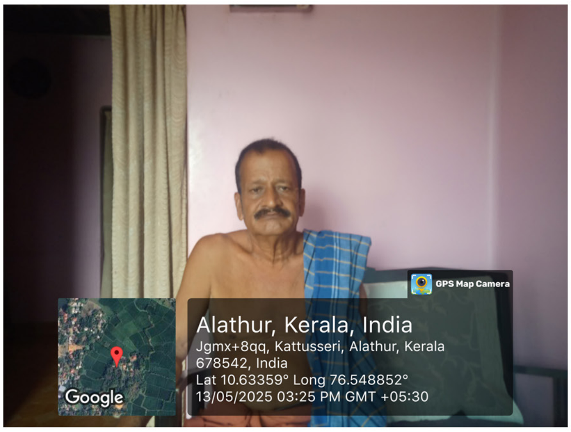
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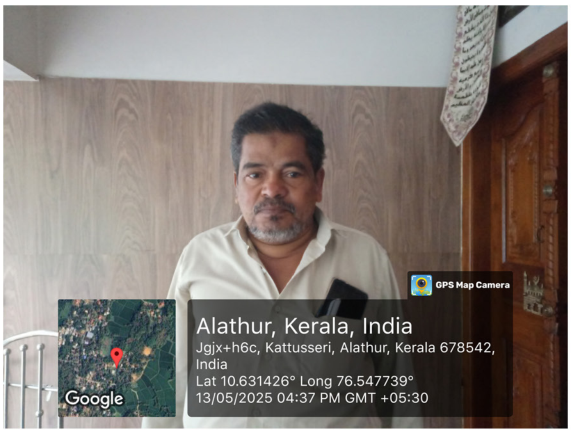
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c - Palakkad


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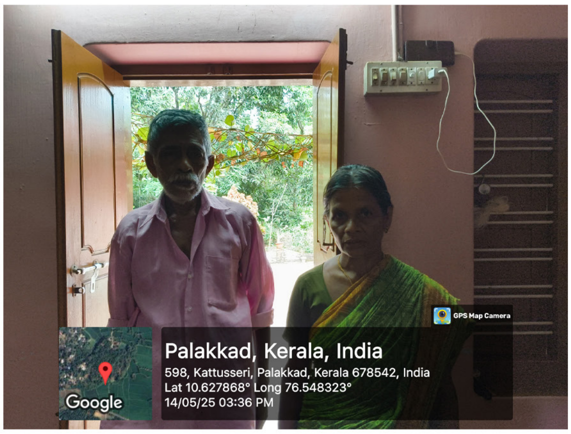
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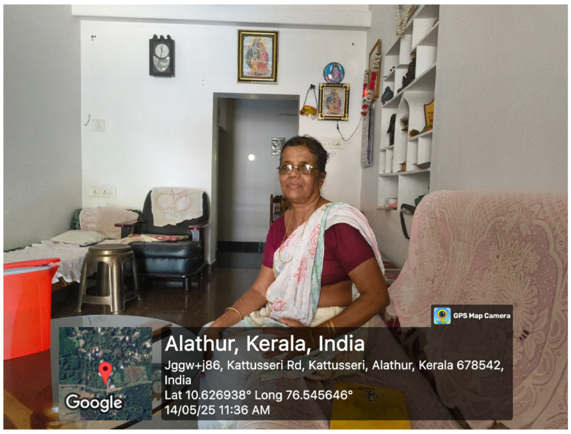
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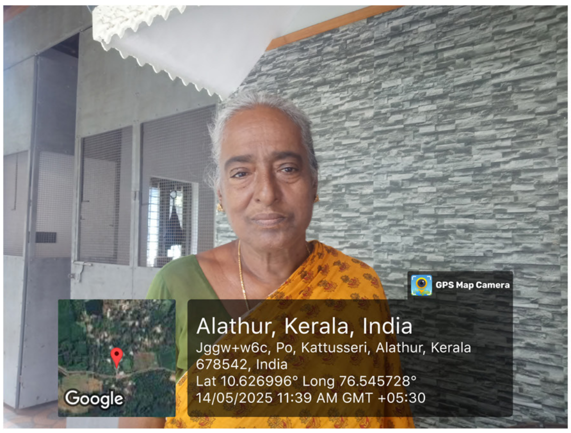
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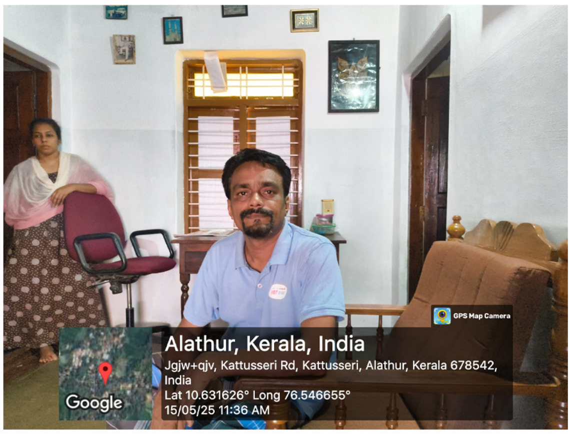
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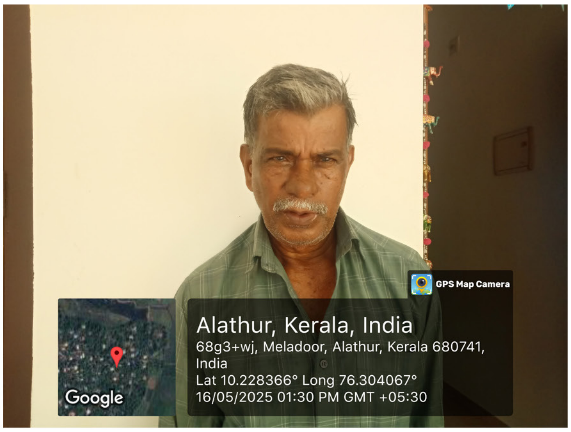
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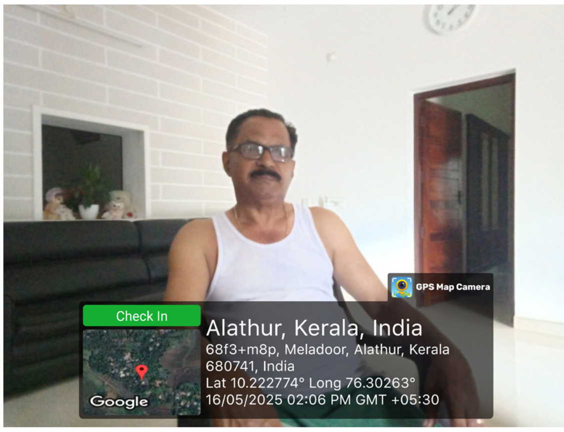
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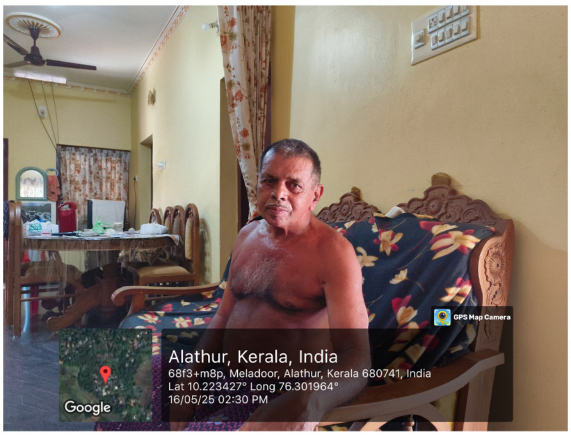
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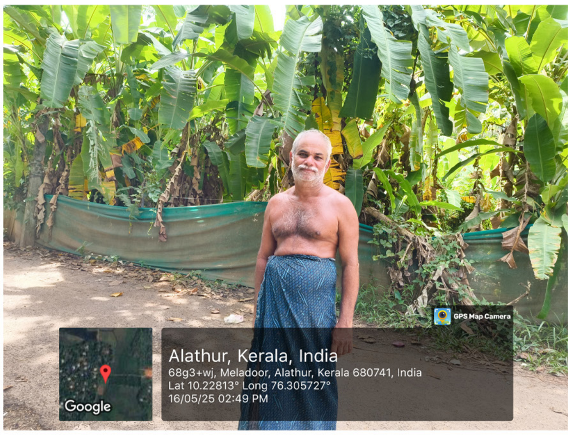
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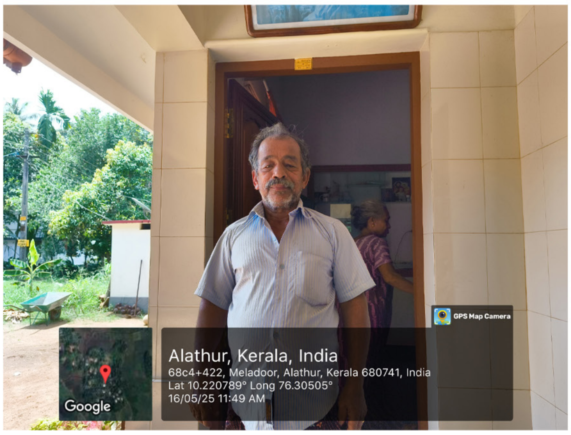
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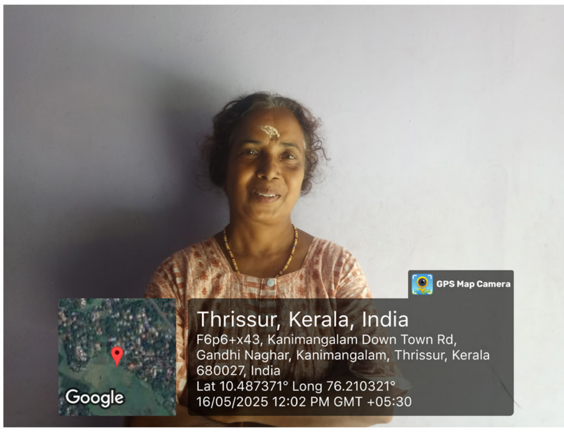
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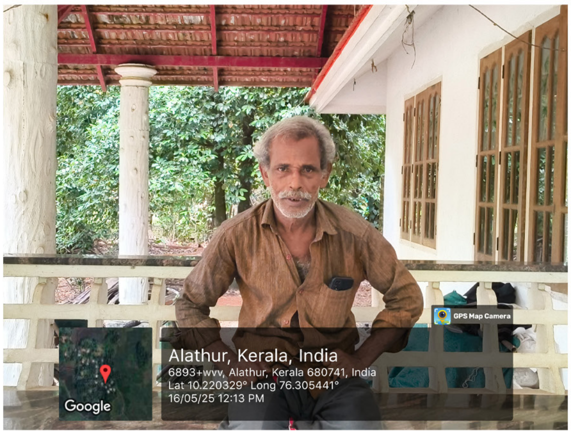
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