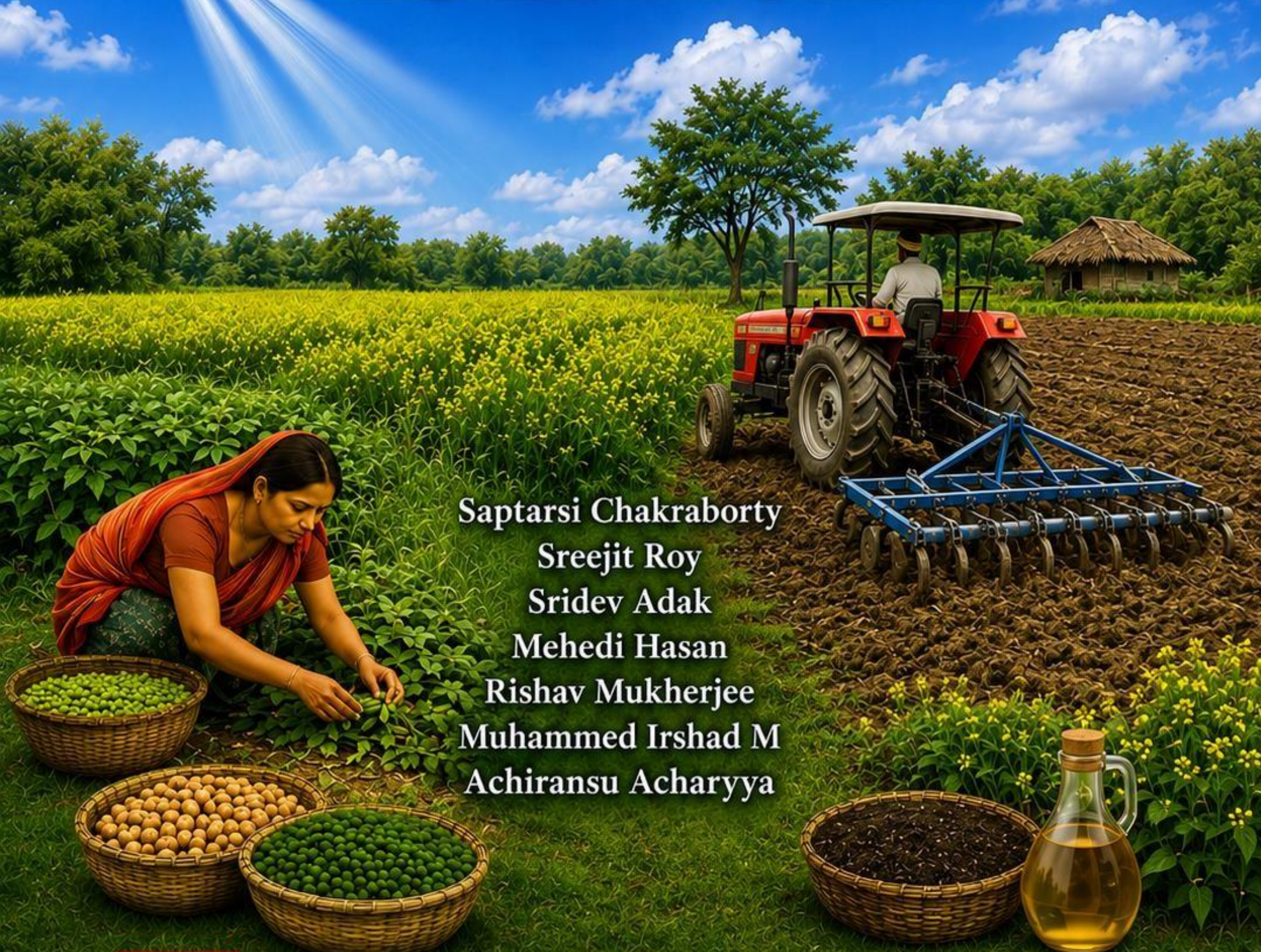
Study Number – 198

Rejuvenating Rice Fallow Lands in West Bengal

Using Remote Sensing and GIS



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Preface

The present study, entitled "Rejuvenating Rice Fallow Lands in West Bengal Using Remote Sensing and GIS," forms part of an All-India Coordinated Study undertaken at the instance of the Directorate of Economics and Statistics, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi. The responsibility for coordination was entrusted to the Agricultural Development and Rural Transformation Centre (ADRTC), Institute for Social and Economic Change (ISEC), Bengaluru. The present report specifically reports the findings and policy recommendations for West Bengal.

Agriculture continues to be a cornerstone of the Indian economy, sustaining the livelihoods of a substantial proportion of the rural population. Despite structural transformation, a significant share of the workforce remains dependent on agriculture, underlining its continued socioeconomic importance. In this context, the research on the rejuvenation of rice fallow lands represents one of the most demanding issues in the agricultural scenario of West Bengal, with a focus on the reasons for the underutilization of rice fallow lands and on exploring pathways that can promote sustainable agricultural practices.

Rice fallow lands refer to those that remain uncropped in the post-kharif season and represent both a challenge and an opportunity. Whereas these lands highlight constraints such as inadequate irrigation, poor soil health, and socio-economic limitations, they also retain residual moisture that can support short-duration crops like pulses and oilseeds. Harnessing this potential requires a blend of scientific innovation, policy support, and farmer participation. Against this backdrop, the present study has utilised advanced tools of remote sensing and geographic information systems (GIS) based secondary data, along with field-based surveys, to provide an inclusive understanding of rice fallow dynamics and their rejuvenation prospects.

The study is distinctive in its dual approach. On one hand, it employs spatial mapping and geospatial analysis to capture district-level variations in fallow land, paddy area, and rice production trends. On the other hand, it incorporates primary data from beneficiary farmers to understand socio-economic realities, perceptions, and constraints in cultivating rice fallow lands. This amalgamation of technological and human viewpoints ensures that the findings are both scientifically strong and socially grounded.

The Government of India launched a scheme "Targeting Rice Fallow Area" (TRFA) in 2016-17 as a sub-scheme under the Rashtriya Krishi Vikas Yojana (RKVY) and later integrated into the National Food Security Mission (NFSM). As per the sampling method, the largest number of beneficiaries of this scheme were found in Birbhum and South 24-Parganas districts in the reference period of 2023-24 (Beneficiary lists were provided by ADAs and DDAs of the respective districts). The study would not have been possible without the cooperation of respondent-farmers in Birbhum and South 24 Parganas districts who are beneficiaries of the aforesaid scheme. Therefore, our gratitude is extended to the family members of sample households for their wholehearted cooperation in responding to the questions during the survey.

The study conducted by the research team led by Mr Saptarsi Chakraborty deserves appreciation, along with other researchers involved in the field survey and mapping. The

successful completion of this study would not have been possible without the guidance and support of several individuals and institutions. Particularly, the contributions of Prof. Parmod Kumar, Head, ADRTC, and Dr. Thomas Felix K., Assistant Professor, ADRTC, ISEC, Bengaluru, in effective coordination and offering suggestions for the study are gratefully recognized. The encouragement and direction provided by the former Directors of the Centre, Prof. B.C. Roy (2018-22) and Prof. D. Bhattacharya (2022-25), during different phases of the study are gratefully acknowledged. The sincere efforts of the researchers, administrative, and supporting staff of the Centre are duly appreciated. We appreciate the important contributions made by the Director, research teams, and employees of the coordinating centre (ADRTC, ISEC, Bengaluru) in carrying out this study. The efforts of Dr. Achiransu Acharyya, Deputy Director, in reviewing this research report are appreciated.

Finally, our gratitude to Dr. Probir Kumar Ghosh, Hon'ble Vice Chancellor, Visva-Bharati, for his kind guidance and encouragement. We acknowledge the support and valuable guidance of the Adviser (AER Division), Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi, in the completion of the study. The support of other officials in the Ministry is also invaluable to us in undertaking this research.

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Date: 15th June, 2026
Place: Agro-Economic Research Centre, Visva-Bharati, Santiniketan

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List of Abbreviations

ACZ: Agro-Climatic Zones

ADRTC: Agricultural Development and Rural Transformation Centre

AERC; VB: Agro-Economic Research Centre, Visva-Bharati

APEDA: Agricultural and Processed Food Product Export Development Authority

AWD: Alternate Wetting and Drying

BGREI: Bringing Green Revolution to Eastern India

DA&FW: Department of Agriculture and Farmers' Welfare

DoFPD: Department of Food & Public Distribution

DoLR: Department of Land Resources

DoPR: Department of Panchayati Raj

GDP: Gross Domestic Product

GIS: Geographic Information System

ISRO: Indian Space Research Organisation

KSARSAC: Karnataka State Remote Sensing Applications Centre

KCC: Kisan Credit Card

KVK: Krishi Vigyan Kendra

MNREGA: Mahatma Gandhi National Rural Employment Guarantee Act

MoA&FW: Ministry of Agriculture and Farmers Welfare

OBC: Other Backwards Class

NFSM: National Food Security Mission

PM-FBY: Pradhan Mantri Fasal Bhima Yojana

PM-Kisan: Pradhan Mantri Kisan Samman Nidhi Yojana

PM-KSY: Pradhan Mantri Krishi Sinchayee Yojana

RKVY: Rashtriya Krishi Vikas Yojana

RS: Remote Sensing

SC: Schedule Caste

ST: Schedule Tribe

SHC: Soil Health Card

TRFA: Targeting Rice Fallow Area

Executive Summary

Background:

Agriculture remains the predominant source of livelihood in rural India. Despite contributing only 17.7% to the Gross Domestic Product (GDP) at current prices, the sector accounts for 42.3% of total employment nationwide. Over the past five years, agriculture has recorded an average annual growth rate of 4.2%. However, in 2023-24, growth decelerated sharply to 1.4%, compared to 4.7% in 2022-23. This slowdown was largely driven by reduced food grain output, resulting from delayed and erratic monsoon patterns (Economic Survey 2023-24, Government of India).

Rice fallow land refers to agricultural fields where rice is cultivated only during the Kharif (monsoon) season, but the land remains uncropped during the subsequent Rabi (winter) season, often for several consecutive years. This practice is generally driven by constraints such as inadequate irrigation facilities, poor soil health, and socio-economic limitations. Despite lying idle in winter, these lands retain residual soil moisture after the Kharif crop harvest, which can support the cultivation of short-duration crops such as pulses, oilseeds, millets, and other drought-tolerant varieties.

The study highlights that rice-fallow land dynamics in West Bengal are spatially diverse and shaped by the interplay of biophysical, socioeconomic, and institutional factors. By integrating remote sensing, GIS, and field-level verification, the research distinguishes rice fallows that can be readily converted from those that require more intensive rehabilitation. It further demonstrates that targeted, place-based interventions have the potential to transform underutilized post-rice lands into productive Rabi cropping systems, thereby enhancing farm incomes and strengthening local food security.

Objectives of the Study:

i. *To map the existing land use and land cover of West Bengal using GIS and Remote Sensing.*
ii. *To assess the status of current rice fallow lands across selected districts of West Bengal.*
iii. *To analyse farmers' perceptions and reasons for not cultivating rice fallow lands.*
iv. *To evaluate the impact of existing policies and programmes related to fallow lands.*
v. *To propose targeted policy measures for sustainable agricultural intensification.*

This study utilized both primary and secondary data to ensure a comprehensive analysis. Primary data were collected through a digital survey administered via the Kobo Toolbox, focusing on key aspects such as the current status of rice fallow lands, the underlying reasons for non-cultivation prior to the TRFA period, and the perceived impact of existing Government policies and programmes.

Secondary data was sourced from official government repositories, including the Department of Agriculture and Farmers' Welfare. These datasets were used to contextualize and enrich the primary findings, offering a broader understanding of the study area and the challenges associated with rice fallow land utilization. The reference period spans two Separate agricultural years for the primary survey: 2015-16 (pre-TRFA implementation) and 2023-24 (TRFA scheme is currently running), which enable a comparative assessment of changes over time. The study employed a cluster-based sampling approach to identify both the study areas and respondents. Two districts were selected based on their relatively higher concentration of beneficiaries under cluster-based demonstrations for the TRFA Scheme (pulses and oilseeds). Within each selected district, two villages were chosen, yielding a total sample of 144 households (HH). An important note is that 4 sample villages are mentioned here, but actually we take the data from 6 different mouzas (Aoyshberia, Kamlakantapur, Khanjanpur, Khordanahala, Kuchli, Simla) under two sample districts; i.e., Birbhum (Kamlakantapur, Khanjanpur, Kuchli) and South-24 Parganas (Aoyshberia, Khordanahala, Simla). This study utilized both primary and secondary data to ensure a comprehensive analysis. Primary data were collected through a digital survey administered via the Kobo Toolbox, focusing on key aspects such as the current status of rice fallow lands, the underlying reasons for non-cultivation prior to the TRFA period, and the perceived impact of existing Government policies and programmes.

Major Findings:

The major findings of the study are summarised below:

I. From secondary data analysis, it is found that the current fallow areas in West Bengal decreased to 244162 hectares in 2020-21 from 348330 hectares in 2000-01. It is also important to note that in our two sample districts (South-24 Parganas and Birbhum), this figure declined significantly (See Appendix, Table A1).

II. It is also seen that through GIS mapping and remote sensing technique (source: ADRTC, Bengaluru, KSRSAC and ISRO), total fallow land declined to 1951892 hectares in 2023-24 from 2173029 hectares in 2020-21 in West Bengal and from the same source, it is evident that paddy area in West Bengal decreased as well, which is a bit contradictory.

III. The calculation of the change in fallow land from 2020-21 to 2023-24 is based on data provided by ADRTC, Bengaluru, KSRSAC, and ISRO, and it is found that the reduction in rice fallow land is extensive in Nadia district.

IV. In case of Paddy area in the period 2016-17 to 2022-23, Alipurduar, both Uttar and Dakshin Dinajpur in northern part, South 24-Parganas, Jhargram of southern part of West Bengal has recorded moderate increase in paddy area (10% to 30%), while Purulia, Nadia, and Howrah has evidenced moderate decline (10% to 30%) in paddy area, while districts like Purba Barddhaman, Purba Medinipur, Hooghly, North 24-Parganas in the southern belt and Maldah, Cooch Behar, Darjeeling, Kalimpong have recorded slight fall in paddy area (10% or less).

V. The highest increase in rice production (in percentage) has occurred in Alipurduar (46.2%), followed by South-24 Parganas (36.73%) and Jhargram (30.76%), all of which are over 30%. So, in that case, South Bengal is represented by several districts. But it is also notable that Paschim Barddhaman, Murshidabad, and Birbhum experienced the largest decline in rice production (over 30%), underscoring the need for district-centric planning. It may be due to crop diversification away from rice, as paddy areas have also decreased by over 30 per cent in these three districts. So, it can be concluded that, overall, North Bengal is a better performer than South Bengal in terms of the percentage change in rice production during the period 2016-17 to 2022-23.

VI. Districts like Murshidabad, Paschim Barddhaman, and Kalimpong experienced moderate to large declines, while southern and certain eastern districts, including South 24 Parganas, Purba Medinipur, and Cooch Behar, recorded significant increases. When the mapped categories are read alongside the district-level data, it becomes clear that the most notable gains in yield were achieved in Cooch Behar, Alipurduar, Purba Medinipur, and South 24 Parganas, each registering double-digit growth, with Cooch Behar leading with 18.77 percent. In contrast, Paschim Barddhaman (-14.16%) and Kalimpong (-12.11%) recorded moderate decreases (ranging from 10% to 30%), while Murshidabad and Maldah also showed slightly negative trends, within the range of 10% or less10% range. Several districts, such as Nadia, Birbhum, and Purulia, remained relatively stagnant with negligible changes.

VII. According to the primary survey, prior to the Targeted Rice Fallow (TRFA) scheme's implementation, i.e., before 2016-17, all sample households (HH) had fallow land; among them, 80% of HH owned fallow land, and the rest had leased-in land, leased-out land, including fallow land. But now, after the implementation of the TRFA scheme, all surveyed HHs do not have any current fallow land. It is evident that 35% of farmers received pulse seeds and 65% received oilseeds in Birbhum (2023-24). In South-24 Parganas, 94% of farmers received pulse seeds, and 6% received Oilseeds.

VIII. Among all sample HH, 35% cultivated oilseeds (Mustard), and the remaining 65% cultivated Pulses (Like Lentil, Green Gram or Moong bean, Grass pea, Khesari bean, Chickpea) were provided by respective Agricultural Departments (Under the TRFA scheme).

IX. It is evident that, as per irrigation sources, wells and tube-wells were placed first (50.7%), followed by canal irrigation (34.7%), river lifting irrigation (11.1%) and lastly, rainwater harvesting (3.5%).

X. But, looking into several methods of irrigation, most of the farmers (97.9%) are using surface irrigation, followed by drip irrigation (2.1%). There are various methods, including surface irrigation (Flood, Basin, Furrow), well and tube-well (50%), canal irrigation (35%), river lifting irrigation (11%), and rainwater harvesting (4%).

XI. A few questions were asked of sample farmers about the need for any training or capacity building programmes, and it was found that 87.5% of farmers are keen to take this facility, whereas 12.5% are not interested. It is also noted that among these, 87.5% of farmers reported these arrangements in Kharif-June to the Early days of November (52.5%), followed by Rabi-November to March (42%) and Summer-March to June (5.5%). So, it can be prescribed that the potential season is kharif, i.e., the pre-sowing period for Pulses and Oilseeds.

XII. It is also asked about the effectiveness of the TRFA scheme: 83% of farmers preferred it, while 17% found it ineffective.

XIII. Therefore, from farmers' perceptions about the weakness of this TRFA scheme, 61% have answered in favour of weakness, along with suggestions, and the remaining 39% did not give any suggestions.

XIV. In case of exploration of non-cultivation of rice fallow land prior to the TRFA period, it is evident that 88 responses have gone to climate vulnerability, followed by water scarcity (73 responses).

XV. The impact of the TRFA scheme's initiative in the two sample districts, i.e., Birbhum and South 24-Parganas districts under West Bengal: before launching the TRFA scheme, the total rice fallow area across the two districts was 62.96 acres, with Birbhum accounting for 37.39 acres and South 24-Parganas for 25.57 acres. But after the intervention of the TRFA scheme, this area is reduced to 52.83 acres in total, resulting in a combined reduction of 10.13 acres of fallow land. Birbhum recorded a decrease of 4.49 acres, whereas South 24-Parganas achieved a slightly higher reduction of 5.64 acres of rice fallow area.

Policy Implications

I. In case of awareness of the different Governmental Schemes, it is seen that most of the sample farmers are aware and have benefited from the Targeted Rice Fallow Area (TRFA) scheme under the National Food Security Mission (NFSM). An interesting thing to note is that the remaining 79 sample farmers gained awareness from us about the TRFA scheme, and then they could relate to it. 22 sample farmers were aware but could not cultivate, while 5 could not relate to it. So, all these 27 farmers cultivated it at their own cost. They also suggested various reasons, such as untimely seed disbursement, poor seed quality, insufficient seed quantity, and insufficient information, which call for a holistic development of extension services.

II. Some suggestions were given from farmers' perspective, like regularizing the policy, increasing the seed amount, and seed quality should be better, timely provision of seeds mainly before sowing time, creating a soil health testing facility, attaching a training facility, providing cash benefits or input subsidies, and flood management and crop insurance are needed.

III. Deployment of demonstration plots and farmer field schools to show zero tillage, relay cropping and residue management in local conditions can be introduced. Also, policymakers have to ensure logistics, such as seed distribution calendars tied to sowing windows and mobile advisories, for timely action.

IV. In case of providing irrigational facilities policy, the government should plan to introduce scaling of farm ponds, community recharge structures, repaired minor canals and low-cost micro-irrigation to enhance residual moisture and enable reliable rabi cropping. Also, promote water-saving practices, such as alternate wetting and drying where applicable, and protective irrigation scheduling for critical crop stages. In terms of the financial model, small capital grants for community ponds, along with microcredit for pump and drip installations.

V. Strengthen Farmer-Producer Organizations and accumulate platforms to reduce transaction costs and secure market access for pulses and oilseeds. Introduction of assured procurement windows or price support during the initial scaling phase to risk management implementation for smallholders. Expand crop insurance and credit products aligned to the rice-fallow calendar and the specific risk profile of second-season crops.

VI. Establishment of district coordination cells that bring together agriculture, water resources, soil health, panchayats and local NGOs to plan, implement and monitor rejuvenation efforts. Ensure participatory planning with farmer groups so interventions reflect local labour availability, cropping preferences and socio-economic realities. Apart from that, align central schemes (TRFA, BGREI, NFSM) with state and district plans to diminish fragmentation and influence co-funding.

Chapter-1: Introduction and Motivation of the Study

1.1. Motivation and Context

Agriculture is still considered a predominant source of livelihood in rural India. Although the Gross Domestic Product (GDP) share of Agriculture and its allied activities was 17.7% at current prices, the employment share across India was 42.3%. Over the past five years, India's agriculture sector has grown at an average annual rate of 4.2%. However, in 2023-24, growth slowed to 1.4%, down from 4.7% in 2022-23. This decline was primarily attributed to reduced foodgrain production, caused by delayed and erratic monsoons (Economic Survey 2023-24, Govt. of India). Around 28.97 thousand sq. kms. (0.88%) of farmland shifted to fallow land during 2005-06 to 2011-12 under agriculture land. Similarly, around 65.10 thousand sq. kms (1.98%) of fallow land and 9.98 thousand sq. kms of barren or waste lands or uncultivable land were converted into farmland under agriculture land in the same period[1]. Despite increasing demand for both agricultural and non-agricultural land, land-use patterns continue to shift, notably marked by the persistent expansion of fallow areas. Although India is a major global producer, its crop yields remain significantly lower than those of other leading agricultural nations due to key structural issues that contribute to low productivity, such as fragmented landholdings, insufficient farm investment, limited mechanisation, and inadequate access to quality inputs (Economic Survey, 2023-24).

However, coming to our study context, Rice fallow land denotes those agricultural fields where rice is cultivated during the Kharif (Monsoon) season, but after that, the cropping land remains uncultivated throughout the Rabi (winter) Season for a period of five years due to some constraints like lack of irrigation facilities, poor soil health, socio-economic factors, etc. These types of land retain residual soil moisture after kharif crop harvesting, which can support the growth of short-duration crops such as Pulses, Oilseeds, and Millets, as well as drought-tolerant crops. (Kumar et al., 2025; Geethika et al., 2024). According to government data, India's total geographical area remains at 328.73 million hectares. Of that, the reported area under land utilisation is 306.65 million hectares, of which 71.53% is currently considered Gross Cropped Area (219.36 million hectares). Besides that, it is also reported that the current fallow area is 10.32 million hectares and 9.91 million hectares as other fallow land (Annual Report, Department of Agriculture & Farmers Welfare, GoI, 2024-25)[2].

Therefore, improving agricultural productivity is the need of the hour for many developing countries, including India. One effective strategy to address this issue is to apply remote sensing and

[1] https://www.mospi.gov.in/sites/default/files/reports_and_publication/statistical_publication/EnviStats/EnviStats2018E/3_Chapter%201-%20Land.pdf

[2] Annual Report 2024–25 – Ministry of Agriculture & Farmers Welfare

geographic information systems (GIS) to improve land-use efficiency and management practices. In West Bengal, a substantial portion of cultivated land lies fallow following the rice harvest, resulting in the underutilization of valuable agricultural resources. Hence, this study aims to promote sustainable agricultural development and increase overall productivity in these regions by leveraging the potential of remote sensing and GIS tools to identify and rejuvenate rice fallow lands.

It is also important to note that in this technological context, the application of remote sensing and geographic information systems (GIS) in agriculture is broadly documented and continues to demonstrate transformative potential. These technologies have proven highly effective in mapping and monitoring agricultural landscapes, identifying cropping patterns, and generating spatially distributed data on soil and crop characteristics. Their integration enables evidence-informed decision-making, offering deeper insights into the complex interplay among social, physical and environmental factors that influence agricultural sustainability. So, GIS in particular has emerged as a critical tool in advancing sustainable agricultural practices by facilitating spatial analysis and data visualization. Remote sensing complements this by providing high-resolution satellite imagery and digital spatial datasets, which are instrumental for exploring the spatial linkages among agroecological conditions, land-use dynamics, and socio-environmental variables (Mathenge et al., 2022). Recent advancements in both fields have significantly enhanced user accessibility, enabling efficient extraction and analysis of thematic data from imagery. These innovations support a wide range of applications from land resource assessment to precision agriculture and continue to expand the analytical capacity of researchers and practitioners across disciplines (Utomowati et al., 2021)[3].

1.2. Importance of Rice Fallows

Rice is a staple crop across much of the world, including West Bengal, India, where it dominates the agricultural landscape. However, following the rice harvest, a considerable portion of this cultivated land is left fallow, resulting in the underutilization of valuable natural and infrastructural resources. These rice fallow lands hold immense untapped potential to boost agricultural productivity and strengthen food security in the region.

So, the possible identification and revitalization of rice fallow lands hold transformative potential for enhancing both local and regional agricultural systems in West Bengal as well as in India, where the rice fallow area is significantly higher. By harnessing remote sensing and GIS technologies, it is possible to accurately map the spatial extent and distribution of these underutilized lands, while also

[3]https://iopscience.iop.org/article/10.1088/1755-1315/683/1/012100/pdf

uncovering the ecological and socio-economic factors contributing to their fallow status. Addressing these challenges not only paves the way for more efficient land use but also strengthens the region's agricultural sustainability and food security.

Types of Fallow Lands: Census and Working Definitions

- **Fallow Lands (excluding Current Fallows):**
  Agricultural land that was previously cultivated but has remained uncultivated for a duration of more than one year and up to five years. These lands are temporarily out of production but retain potential for future cultivation.

- **Current Fallows:**
  Land that is left uncultivated for one agricultural year or less. This typically includes fields that are intentionally rested between cropping cycles within a short-term period.

- **Rice-Fallow (Working Definition):**
  Croplands where rice is cultivated during the Kharif season (monsoon) and left uncultivated during the Rabi season (winter). This seasonal fallowing is common in rainfed rice-growing regions and reflects cropping patterns influenced by water availability and agro-ecological conditions.

1.3. Challenges in Rejuvenating Rice Fallows

The rejuvenation of rice fallow lands in West Bengal presents a complex set of challenges that must be systematically addressed. A key constraint is the absence of comprehensive, up-to-date datasets detailing the spatial extent and characteristics of these lands. Traditional data collection methods often fall short in capturing the dispersed and heterogeneous nature of rice fallow areas, which vary significantly in their biophysical and socioeconomic profiles.

Moreover, the interplay of multiple factors, such as climate variability, soil moisture stress, poor soil health, lack of irrigation facilities, mechanisation, and local livelihood dynamics, further complicates their effective utilization (Ghosh et al., 2016). Constraints such as drought, seasonal submergence and poor soil fertility have consistently hindered optimal land use, especially in Eastern Indian States (Jha et al., 2012).

To overcome these barriers, a holistic and evidence-driven strategy is essential. This includes integrating remote sensing, GIS, and advanced geospatial analytics with field-level data and active stakeholder engagement. Such an approach can enable precise mapping, informed decision-making and sustainable management of rice fallow lands across the region.

1.4. Need and scope of the study:

Despite several agronomic and logistical challenges, the rice-fallow system offers significant potential for cultivating a second crop after the rice harvest with the support of improved soil and crop management practices, strategic crop selection, and an appropriate variety. Among the viable options, low-input pulses are the most promising for intensifying rice-fallow production systems due to their adaptability and resource efficiency. To enhance the survival and productivity of pulses in rice fallows, a suite of complete crop management techniques can be employed. These include zero-tillage farming, relay cropping, residue retention, mulching, seed priming, establishing farm ponds for protective irrigation, and micronutrient application. Together, these interventions can significantly improve crop performance, resource-use efficiency, and the overall sustainability of rice-fallow agroecosystems (Ghosh et al., 2016).

The substantial rise in fallow land, particularly rice fallow in States like Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu and West Bengal, has emerged as a pressing concern. This study presents field-based insights to inform more effective policy interventions that not only identify current fallow areas, especially rice fallow land, but also facilitate their conversion into sustainably cultivable land. These findings align with and support the Ministry of Agriculture & Farmers Welfare's Targeted Rice Fallow Areas (TRFA) Scheme, launched in 2016-17 as a sub-scheme under the Rashtriya Krishi Vikas Yojana (RKVY) and later integrated into the National Food Security Mission (NFSM).

The research investigates the underlying causes of land fallow in the above-mentioned states, focusing on rice fallow regions. Key factors examined include shifts in agricultural practices, land degradation, water scarcity, limited access to inputs and technology, land tenure issues and socio-economic dynamics that contribute to the abandonment of cultivation.

Beyond identifying causes, the study explores the broader implications of rice fallow land for rural livelihoods, including impacts on food security, income generation, migration trends, and community well-being. It also considers environmental dimensions, including effects on biodiversity, water resources and climate resilience. Importantly, the study evaluates the potential of remote sensing and GIS technologies to accurately map and revitalize rice fallow lands, offering a strategic pathway toward sustainable agricultural development in selected Indian states.

1.5. Objectives of the Study

A. To map the existing land use and land cover of West Bengal using GIS & Remote Sensing.
B. To assess the status of current rice fallow lands across selected districts of West Bengal.

C. To analyse farmers' perceptions and reasons for not cultivating rice fallow lands.
D. To evaluate the impact of existing policies and programmes related to fallow lands.
E. To propose targeted policy measures for sustainable agricultural intensification.

1.6. Study Areas: Involved Agro-Economic Research Centres/Units for the study

There were 11 states involved in this study: Assam, Bihar, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, and West Bengal. The study was coordinated by ADRTC, ISEC, Bengaluru, and we served on behalf of West Bengal (Agro-Economic Research Centre, Visva-Bharati, Santiniketan).

West Bengal, situated in eastern India, is the country's fourth-largest state by population, with a population of 10.02 crore and a 7.07% share of India (Technical Group on Population Projections, Ministry of Health and Family Welfare, 2025 estimates), and is a vital contributor to its agricultural economy. Also, renowned for its diverse agro-climatic zones and rich farming traditions, the state plays a pivotal role in national food production. In particular, West Bengal is one of India's leading rice-producing states, contributing around 11.32% to the country's total rice output, according to recent government estimates (Directorate of Economics and Statistics, MoA&FW-CEIC Data, 2023; 3rd Advance Estimates-APEDA, 2023-24).

1.7. Factors Affecting Rice Fallow Dynamics

The utilization of rice fallow lands in South (specifically in Andhra Pradesh) and Eastern Indian States, as well as in West Bengal, is governed by a complex interaction of biophysical, socioeconomic and institutional factors. Key biophysical determinants, such as soil fertility, water availability, and climatic conditions, directly affect the feasibility of post-rice cultivation in fallow fields (Phenica et al., 2018; Jha et al., 2012).

Equally important are the socioeconomic drivers, including the availability of labourers, access to agricultural inputs, and the strength of market linkages, all of which shape farmers' decisions on whether to bring fallow lands under cultivation. These factors, operating in tandem, influence both the potential and the constraints of transforming rice fallows into productive agro-ecosystems.

Institutional factors, including government policies, agricultural extension services and access to credit and subsidies, play a pivotal role in influencing the utilization of rice fallow lands. These mechanisms can either enable or constrain farmers' capacity to bring rice fallow areas under cultivation, depending on their design and implementation (Beerannavar & Dhananjaya, 2021; Negalur et al., 2017; Khedwal et al., 2023; Sharma et al., 2016).

1.8. Policy Interventions for Fallow Land Rejuvenation

In the past few years, the Government of India has introduced several policy initiatives to address the challenge of underutilized agricultural lands, particularly rice fallow areas. Among these, the Bringing Green Revolution to Eastern India (BGREI) programme was launched in 2010–11 under the Rashtriya Krishi Vikas Yojana (RKVY). This programme aims to boost agricultural productivity and promote crop diversification in the eastern states of India, including West Bengal, Bihar, Odisha, Jharkhand and others.

Accompanying the previous effort, the Targeted Rice Fallow Area (TRFA) scheme, launched by the Ministry of Agriculture and Farmers' Welfare in 2016-17, focuses specifically on identifying and revitalising rice fallow lands for the cultivation of pulses and oilseeds. These interventions are designed to enhance resource-use efficiency, improve farmers' incomes, and strengthen food and nutritional security in rainfed and low-productivity regions.

1.9. Identifying Potential Crops for Rice Fallows

Drawing on the biophysical and socioeconomic characteristics of rice fallow lands, this study investigates the potential for cultivating alternative crops, such as pulses (E.g., Lentil, Green Gram, Mung Bean, chickpea, grass pea) and oilseeds (E.g., Mustard and others) during the post-rice fallow season. These crops offer promising avenues for enhancing food and nutritional security, increasing farm incomes and strengthening climate resilience (Khedwal et al., 2023; Rachman et al., 2021; Negalur et al., 2017; Jha et al., 2012). Additionally, the adoption of suitable crop rotations and intercropping systems can significantly improve soil fertility and contribute to long-term agricultural sustainability (Phenica et al., 2018; Negalur et al., 2017; Ghosh et al, 2016; Jha et al., 2012).

That is why this study adopts a participatory approach to promote the rejuvenation of rice fallow lands in West Bengal, emphasizing the cultivation of water-efficient and short-duration crop varieties. It integrates improved soil and water management practices with active engagement of local farming communities to understand their needs, constraints, and crop preferences.

By involving farmers directly in the research and decision-making process, the study ensures that proposed interventions are contextually relevant, socially acceptable and more likely to be sustainably adopted. Combining remote sensing data, field-based assessments, and stakeholder consultations, the study aims to develop a comprehensive and scalable framework to enhance the productivity and resilience of rice fallow ecosystems, ultimately contributing to regional agricultural development and food and nutritional security.

Therefore, in a nutshell, the findings of this study are poised to offer actionable insights and context-specific solutions for the productive utilization of rice fallow lands in West Bengal. By addressing key agronomic and socio-economic challenges, the research aims to support enhanced agricultural productivity, promote crop diversification and enhance provincial food security.

In terms of economic and livelihood impacts, the rejuvenation of rice fallow lands in West Bengal holds considerable potential to improve the economic well-being and livelihoods of local farming communities. By cultivating alternative crops during the post-rice fallow season, farmers can diversify their income streams and improve overall farm profitability.

The strategic introduction of high-value crops, such as pulses and oilseeds, not only supports farm income but also improves household food and nutritional security (Surya et al., 2020; Singh et al., 2019). These interventions can play a pivotal role in strengthening climate resilience and promoting sustainable agricultural development in the region.

1.10. Review of Literature:

1.10.1. Rejuvenating Rice Fallow Land

The concept of rice-fallow land is already clear to us: agricultural areas left uncultivated after rice harvest in the kharif season, which are considered a valuable yet underutilised resource with significant potential to enhance agricultural productivity and food security globally. It is also notable that permanent fallow land includes all land that was used for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years after the paddy harvest. It is also referred to as “other Rice-fallow land”[4]. The underutilization of these lands is primarily due to soil moisture depletion after rice harvest, delayed sowing, and insufficient irrigation facilities (Singh et al., 2016). In India, these lands offer promising opportunities for reactivation through strategic interventions. The integration of remote sensing and geographic information system (GIS) technologies can play a crucial role in identifying, mapping, and managing these fallow areas, thereby facilitating their transition into productive cropping systems (Mathenge et al., 2022; Chavan et al., 2020).

1.10.2. Connecting Remote Sensing and GIS for Agricultural Sustainability

Remote sensing and geographic information systems (GIS) have emerged as indispensable tools in modern agriculture, offering cost-effective and scalable solutions for monitoring, planning and managing crop production (Chavan et al., 2020). These technologies enable the identification of

[4] https://mospi.gov.in/sites/default/files/Statistical_year_book_india_chapters/Agriculture-writeup.pdf

cropping patterns, the development of detailed agricultural land-use databases and, interestingly, the spatial mapping of specific crops, including bamboo (Utomowati et al., 2021; Kumar, 2008).

By integrating spatial data with ancillary information such as soil profiles, topography, and climatic variables, remote sensing and GIS provide a holistic view of the agricultural landscape. This comprehensive approach supports evidence-based decision-making, enhances resource efficiency and contributes to agricultural sustainability in the long run (Mathenge et al., 2022).

1.10.3. Latest Situation of Rice Fallow Land in West Bengal

In the period from 2020-21 to 2023-24, the amount of fallow land in India declined from 21.73 lakh hectares to 19.51 lakh hectares. The mapping and associated data were generated as part of the study titled "Rejuvenating Rice Fallow Land in Karnataka Using Remote Sensing and GIS" (2025), conducted by the Agricultural Development and Rural Transformation Centre (ADRTC), ISEC, Bengaluru. The study was conducted with technical support from the Karnataka State Remote Sensing Applications Centre (KSRSAC) and the Indian Space Research Organisation (ISRO). Therefore, despite prior use for rice cultivation, a substantial area of land continues to lie fallow post-harvest, highlighting a crucial opportunity for ecological rejuvenation and enhanced agricultural productivity.

1.10.4. Rejuvenation Approaches

Multiple strategies have been explored to revitalise rice fallow lands, harnessing the analytical power of remote sensing and GIS technologies. One prominent approach involves developing integrated, sustainable rice-farming models rooted in the concepts of Rice Estate Community and Smart Farming. These models advocate land consolidation, institutional strengthening, and the adoption of targeted cultivation techniques and input packages to enhance productivity and profitability, particularly on marginal lands.

As said earlier, another complementary approach centres on the spatial and temporal mapping of cropping patterns using satellite imagery and GIS software. This method enables researchers to identify trends in crop distribution and abandonment, offering critical insights into the underlying causes of the persistence of fallow land. Such data-driven analysis supports the design of precise, location-specific interventions to encourage the reactivation of rice fallow areas (Chavan et al., 2020; Utomowati et al., 2021).

1.10.5. Soil Fertility Restoration

Outside of crop management, restoring soil fertility is important for the successful rejuvenation of rice fallow lands (Kumar et al., 2019). Research indicates that nutrient reduction (particularly the decline in potassium levels) significantly limits the productive capacity of rice fallow areas. To address these constraints, targeted interventions such as the application of balanced fertilizers and the adoption of soil conservation measures like terracing have proven effective. These practices not only enhance soil health but also unlock the agricultural potential of fallow lands, paving the way for sustainable cultivation (Sharma & Datta, 1994; Sharma et al., 2009; Chandna & Mondal, 2020).

1.10.6. Diversifying Cropping Pattern

Rejuvenating rice-fallow lands requires more than soil restoration; it calls for a strategic shift in cropping patterns. Integrating alternative crops such as pulses and oilseeds (which can fix atmospheric nitrogen) into the existing agricultural system has proven effective in enhancing soil fertility, promoting nutrient cycling, and strengthening the overall resilience of farming practices, especially in the eastern Himalayan region (Baishya et al., 2019). This diversification helps disrupt the monocultural cycle of cropping, often linked to the neglect of rice fallows, opening the door to more ecologically balanced and economically practical cultivation systems.

Additionally, introducing crop rotation suggests added value in rejuvenating rice fallow lands. Leguminous crops can thereby reduce dependence on synthetic fertilizers (Yu et al., 2013). In the meantime, oilseed cultivation offers viable income opportunities and broadens the agricultural base, fostering greater resilience and economic sustainability within the farming system (Gupta & Gupta, 2015).

1.10.7. Application of Precision Agriculture for Rice Fallow Land Rejuvenation

Precision agriculture technologies, such as sensors, drones and data analytics, offer transformative potential for revitalizing rice fallow lands (Prabhudeva et al., 2017). These tools generate real-time, site-specific insights into soil health, crop conditions and environmental variables, enabling targeted interventions and optimized input use. As a result, they are contributing to boosting greater efficiency, sustainability and productivity in agricultural systems (Queiroz et al., 2020). Integrating precision agriculture to rejuvenate rice fallow lands empowers farmers and researchers to make informed decisions and manage resources more efficiently. With access to spatially explicit data, tailored strategies can be developed to address the unique constraints and opportunities of each fallow plot, thereby ensuring long-term viability and enhanced agricultural output (Prabhudeva et al., 2017).

1.10.8. Integrated Nutrient Management

Ensuring the long-term sustainability of rice-fallow land rejuvenation requires a robust integrated nutrient management (INM) strategy. This approach emphasizes the judicious combination of organic and inorganic fertilizers, the incorporation of nitrogen-fixing crops, and finally, the adoption of soil microbiome enhancement practices by the farming community. Together, these measures restore soil fertility, reduce dependency on synthetic inputs and strengthen the ecological resilience of agricultural systems. A well-structured INM plan is pivotal to the success of rice fallow land revitalization.

Balanced nutrient application improves soil health and optimizes nutrient availability. The inclusion of nitrogen-fixing species (such as legumes) naturally replenishes soil nitrogen, minimizing the requirement for chemical fertilizers. Additionally, fostering a diverse and functional soil microbiome enhances biological activity, nutrient cycling and long-term soil productivity (Maseko et al., 2020).

1.10.9. Water Resource Management

Effective water resource management is a vital tool for the rejuvenation of rice fallow lands, especially in those places where rainfall patterns are increasingly erratic, and water scarcity poses a growing challenge. To address these constraints, a combination of strategies can be employed, such as rainwater harvesting systems to capture and store seasonal runoff, water-efficient irrigation techniques to minimize wastage and the cultivation of drought-tolerant crop varieties suited to low-moisture conditions. Together, these interventions can optimize water use and strengthen the long-term possibility of rice-based farming systems in vulnerable landscapes (Tuong et al., 2005).

1.10.10. Conservation Agriculture Practices

The adoption of conservation agricultural practices offers a transformative pathway for revitalizing rice fallow lands across eastern India. Core methods such as minimum tillage, crop residue management, and cover cropping significantly enhance soil health and system resilience (Kumar et al., 2019).

By reducing or eliminating tillage, farmers can preserve soil structure and foster the development of beneficial soil biota, which refers to the combined collection of living organisms, such as fungi and microorganisms, within a particular region (Munodawafa & Zhou, 2008). This biological activity improves water infiltration and retention, limiting surface runoff that minimize erosion. Retaining crop residues in the field further safeguards the soil from direct exposure to rainfall and wind, aiding in moisture conservation and reducing degradation. The strategic use of cover crops (particularly legumes, i.e., the crops under the pea family and grasses) refills soil organic matter, fixes atmospheric nitrogen, and improves nutrient cycling. These practices not only break the typical monocultural cycle of the rice fallow system but also contribute to long-term ecological sustainability and productivity (Venkateswarlu et al., 2007).

1.10.11. Marginal Land Rehabilitation

As mentioned earlier, rice fallow lands that have been degraded or abandoned, due to environmental pressures and socioeconomic constraints, require a comprehensive rehabilitation strategy. This should encompass integrated soil and water conservation practices, the adoption of context-appropriate agroforestry systems, the promotion of participatory land-use planning, and the development of management capabilities. Such an approach not only restores ecological function but also empowers local communities to sustainably steward their landscapes (Brown & Lugo, 1994).

Therefore, this is associated with adopting soil and water conservation techniques (such as terracing and rainwater harvesting) to restore soil fertility and enhance moisture retention. Introducing agroforestry systems, which blend trees with crops, offers multiple benefits: diversifying farm outputs, improving nutrient cycling, and generating supplementary income for farmers (Agroforestry for Landscape Restoration, 2023). Equally vital is the active participation of local communities in land-use planning and management. Their involvement ensures that rehabilitation efforts are contextually grounded, socially inclusive, and sustainable over the long term.

1.10.12. Satellite-based Monitoring

Satellite-based monitoring and remote sensing technologies are pivotal for assessing and guiding the rejuvenation of degraded rice-fallow lands. These tools enable continuous observation of changes in land cover, crop productivity, and environmental indicators, offering spatially explicit, real-time data that inform adaptive management strategies (Chandna & Mondal, 2020).

By adopting these technologies, researchers and policymakers can evaluate the effectiveness of interventions, fine-tune approaches, and ensure long-term ecological and agricultural sustainability. The integration of satellite-derived insights into the planning framework strengthens evidence-based decision-making and enhances the resilience of restoration efforts (Panwar et al., 2022).

1.10.13. Geospatial Mapping for Strategic Rejuvenation of Rice Fallow Lands

Geospatial tools such as Geographic Information Systems (GIS) offer powerful capabilities for identifying and revitalizing rice fallow lands. By creating detailed spatial databases, these tools can map the distribution of fallow areas and pinpoint zones suitable for targeted interventions (Gumma et al., 2018).

Beyond mapping, GIS platforms can integrate diverse datasets, including soil profiles, climatic trends and socioeconomic variables, to build a holistic understanding of the agricultural landscape. This multi-layered insight enables researchers and planners to make evidence-based decisions, design context-specific strategies, and optimize resource allocation for effective and sustainable land rejuvenation.

1.10.14. Policy and Regulatory Frameworks for Rice Fallow Land Rejuvenation

Robust policy and regulatory frameworks are critical to advancing and scaling rice-fallow land rejuvenation efforts in the states. To foster widespread adoption, policymakers should implement measures such as:

i. Financial incentives that encourage farmers to embrace sustainable land-use practices.
ii. Enhanced access to extension services and agricultural inputs to support their transition (Dionisio Perez-Blanco et al., 2023) and

iii. Targeted programs promoting sustainable land management tailored to local contexts (Piñeiro et al., 2020). So, these interventions help create an enabling environment that motivates farmer participation and reduces systemic barriers. By addressing economic, technical and institutional challenges, policy frameworks can accelerate the uptake of sustainable practices and ensure the long-term viability of rejuvenation initiatives across the targeted regions, as mentioned earlier.

1.10.15. Climate Change Adaptation

As climate change continues to disrupt agricultural systems, it becomes increasingly vital to rejuvenate rice fallow lands through strategies that are resilient to environmental variability and weather extremes. The integration of climate-smart agricultural practices plays a key role in strengthening the adaptive capacity of these vulnerable landscapes (Kumar et al., 2019).

A promising approach involves cultivating drought-tolerant crop varieties bred to withstand water scarcity while maintaining yields under shifting climatic conditions. Complementing this, the implementation of water-efficient irrigation technologies (such as drip and micro-irrigation) can significantly enhance water-use efficiency. These systems not only conserve limited water resources but also reduce crop vulnerability during the dry season (Dionisio Perez-Blanco et al., 2023).

Additionally, adopting improved soil management techniques, such as enriching soil with organic matter and applying conservation agriculture practices, can be highly effective in boosting soil health and water retention capacity. These enhancements not only enhance the resilience of agricultural systems against climate-induced stresses but also lay the foundation for the long-term sustainability of rice-fallow land rejuvenation initiatives (Upadhyay et al., 2021).

1.10.16. Reasons for leaving fallow land

Several interlinked factors contribute to land being left fallow after rice cultivation, especially in Eastern India. A primary constraint is the limited access to irrigation, especially during the non-monsoon season. Due to a shortage of dependable water sources, farmers are unable to maintain year-round cropping, often leaving land uncultivated (Yaligar et al., 2017).

Another significant challenge is the deterioration of soil health due to intensive monoculture practices. Continuous rice cultivation without adequate soil management or nutrient replenishment depletes organic matter and essential nutrients, thereby reducing land productivity. In response, farmers may leave fields fallow to allow for natural soil regeneration. Along with these, socioeconomic burdens also play a serious role. Labour shortages, limited access to agricultural inputs and the low profitability of certain crops often compel farmers to redirect their efforts toward more viable alternatives. Consequently, less-productive rice fallow lands are frequently abandoned or deprioritized, especially in Bhagalpur, Bihar (Kumari & Badal, 2020).

1.10.17. Perception on cultivating the fallow land

Studies indicate that farmers suffering from rice fallows are willing to cultivate rice fallow lands on condition that they receive adequate support in terms of infrastructure and resources. Farmers clearly recognize the potential benefits of utilizing these underused lands, including increased food production, higher income, and greater sustainability within rice-based cropping systems (Kumari & Badal, 2020).

Yet, several persistent challenges continue to hinder their efforts. Chief among these is inadequate access to irrigation. Besides, the limited availability of suitable crop varieties for post-rice cultivation and the increasing unpredictability of rainfall patterns are also hampering those farmers. These constraints collectively reduce the feasibility of year-round cultivation and discourage farmers from investing in fallow land rejuvenation (Kumar et al., 2019).

1.10.18. Knowledge Dissemination

Operative knowledge dissemination and meaningful stakeholder engagement are vital tools for the successful implementation of rice-fallow land rejuvenation strategies. By actively involving farmers, policymakers and other key stakeholders, researchers can ensure that interventions are context-specific and responsive to the real-world challenges faced by farming communities (Xie & Wu, 2020).

To facilitate this, it is essential to establish open communication channels and strong feedback mechanisms that promote the exchange of ideas and the integration of local knowledge. Such collaborative frameworks help uncover site-specific constraints and opportunities within the rice fallow land ecosystem, ensuring that proposed solutions are both practical and inclusive (Burgers et al., 2005).

To maximise the reach and impact of rice fallow land rejuvenation strategies, researchers should actively utilize diverse dissemination platforms, including workshops, field demonstrations, and agricultural extension services. These channels serve not only to communicate the benefits and best practices of the interventions but also to build farmers' capacity through hands-on learning and contextual guidance. By equipping farmers with the necessary knowledge and practical skills, they are empowered to take ownership of the initiatives, contribute meaningfully to their implementation, and ensure long-term sustainability at the grassroots level (Gupta & Gupta, 2015).

Therefore, the rejuvenation of rice fallow lands in West Bengal presents a complex, multidimensional challenge that demands a holistic and integrated approach. Deploying satellite-based monitoring, geospatial mapping and climate-smart agricultural practices can significantly enhance the effectiveness of these efforts. To ensure long-term sustainability, it is essential to address the social, economic and environmental factors that shape land-use decision-making. By fostering an enabling environment, policymakers and researchers can support the adoption and continuity of rejuvenation initiatives across diverse agro-ecological zones.

A review of the existing literature highlights the compelling rationale for cultivating rice fallow lands. Farmers recognize the potential benefits that include increased food production, improved household income and greater resilience within rice-based cropping systems. However, several constraints hinder their ability to utilize these lands effectively. These include limited access to irrigation, scarcity of suitable crop varieties and climate change.

Robust knowledge dissemination and inclusive stakeholder engagement are required to overcome these barriers. Empowering farmers with context-specific information, practical skills, and institutional support will enable them to become active participants in transforming fallow lands into productive assets. The full potential of West Bengal's underutilized rice fallow landscapes can be unlocked through the alignment of interventions with local realities and farmer priorities.

1.11. Structure of the report

The **Introduction and Motivation of the Study**, i.e., the current chapter, provided an overview of the study, including a brief literature review, outlining its objectives and emphasizing the importance of rejuvenating rice fallow lands in India, particularly in West Bengal (and the Eastern and North-Eastern Indian States). It discussed the broader context of land use changes and their implications for agriculture and food security. Additionally, the section highlighted existing research gaps and underscored the role of remote sensing and GIS technologies in addressing these challenges. In addition, the Literature Review summarized key studies on the application of remote sensing and GIS for monitoring rice fallow lands. It also examined policy initiatives aimed at land rejuvenation, along with the practical challenges encountered during their implementation. By synthesizing previous research and policy frameworks, this chapter established a compact foundation for the study's methodology and analytical approach.

The next **Methodology** (Chapter II) will detail the data sources employed in the study, including satellite imagery, field-based surveys, and relevant secondary datasets. It will elaborate on the analytical techniques used to delineate rice fallow lands and evaluate their suitability for cultivation. Furthermore, this chapter will provide a comprehensive framework for examining the socio-economic and environmental factors contributing to the non-utilization of these lands. Insights from primary data collection will be integrated to support this analysis and provide a grounded understanding of the barriers to rice-fallow land rejuvenation.

Agricultural Land Use Dynamics and Paddy Cultivation Trends in West Bengal-A Spatial Analysis (Chapter III) will present a comprehensive examination of agricultural land use patterns (Current Fallows, Other than Current Fallows, Total Fallow Lands and Area Sown more than once) across multiple scales, such as national (India), state (West Bengal), and district-level scenarios. It will analyze the spatial distribution of paddy cultivation, identify key irrigation sources and map irrigated regions. In addition, the chapter will explore trends in agricultural land use change and assess their implications for paddy cultivation systems. By establishing the geographical and agricultural context, this chapter will lay the groundwork for subsequent analytical sections, enabling a deeper understanding of the factors shaping rice-fallow land dynamics in West Bengal.

Mapping and Analyzing Paddy Area, Rice Production and Yield in West Bengal (Chapter IV). This chapter will present a comprehensive spatial analysis of paddy area, rice production, and yield of paddy across the districts of West Bengal, emphasizing their distribution patterns and temporal dynamics. Remote sensing and GIS methodologies are applied to investigate these district-wise variations by employing both the maps and figures of percentage change of paddy areas, rice production, and yield between 2016-17 and 2022-23. This period is chosen because the TRFA implementation began in 2016-17 and the latest secondary data are available in 2022-23. The insights derived from this analysis will inform a spatially detailed, methodologically rigorous, and policy-oriented assessment of paddy dynamics in West Bengal.

Exploring the Non-Cultivation of Rice Fallow Lands in West Bengal: Insights from Primary Data (Chapter V) presents key insights drawn from field surveys and stakeholder interviews that offer a ground-level understanding of the factors contributing to the non-cultivation of rice fallow lands in West Bengal. It examines the socio-economic, institutional, and environmental dimensions that shape land-use decisions and sheds light on the lived experiences and perspectives of farmers and policymakers. Through this analysis, the chapter identifies the core challenges and emerging opportunities for re-integrating fallow lands into productive agricultural cycles.

Conclusion and Policy Implications (Chapter VI). Finally, the study's key findings are summarised, and policy recommendations for enhancing the effective utilisation of rice fallow lands are presented. Strategies for integrating remote sensing-based monitoring with existing policy frameworks are proposed to support sustainable agricultural development. Through this synthesis, contributions are made to the broader discourse on food security and land resource management in West Bengal.

Chapter-2: Methodology

The study employed a mixed-methods approach, drawing on both primary and secondary data sources. As outlined earlier, the current land use and land cover of West Bengal were mapped using GIS and Remote Sensing (RS) technologies, with particular emphasis on the status of rice fallow lands. The underlying factors contributing to the non-cultivation of these lands were investigated, along with an exploration of farmers' perceptions of their potential for agricultural use. Existing policies and programs related to rice fallow land, especially the Targeted Rice Fallow Area (TRFA) scheme, were critically assessed. Based on the findings, policy measures are proposed to support the sustainable utilization of rice fallow lands and advance agricultural resilience in West Bengal.

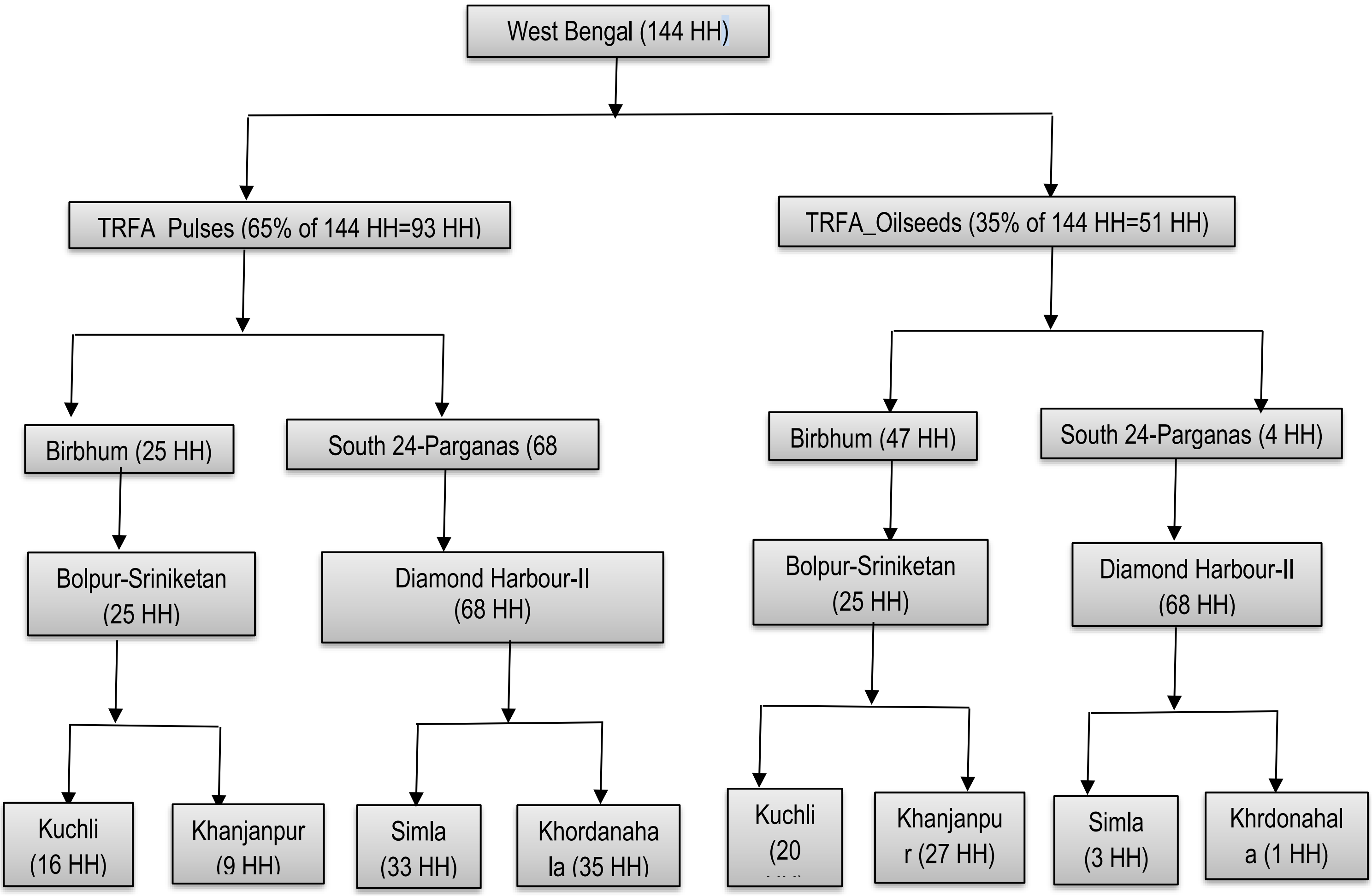
2.1. Data sources and methodology used for the identification of rice fallow lands

The data sources utilized in this study are detailed in Table 2.1. We mentioned earlier that this study draws on both secondary and primary data. The secondary data provided by ADRTC, Bengaluru, were obtained with the help of the Karnataka State Remote Sensing Application Centre (KSRSAC) and the Indian Space Research Organisation (ISRO). There are various remote sensing techniques like Sentinel-Inverse Synthetic Aperture Radar (ISAR), 2B Medium Scale Integration (MSI), India's Earth Observation Satellite (EOS) Synthetic Aperture Radar (SAR) imagery and for spatial analysis, the study employed a combination of optical data from the Visible and Near Infrared (VNIR) spectrum and Synthetic Aperture Radar (SAR) imagery (Felix et al., 2025). After obtaining data for West Bengal, we recalculated the data and created a map using R and ArcGIS.

Table 2.1: Data Products and Their Sources for Rice Fallow Land Identification and Area Estimation or Mapping and Field Survey

Sl. No.	Data Products	Satellite/Ground-Based
1	Reference Data	MoA&FW, DES and DA&FW, New Delhi
2	Secondary Data	ADRTC, Bengaluru
3	Crop map preparation (16-20 days' time composites)	Sentinel-1SAR and & 2B MSI, India's EOS-04 SAR and ADRTC, Bengaluru
4	Rice Fallow Mapping for West Bengal	AERC, Visva-Bharati, Santiniketan
5	Primary Data (Field Survey in West Bengal)	AERC, Visva-Bharati, Santiniketan

2.2. Showcasing the Sampling Design and Sample Size for Primary Survey: The Flow Chart



The study employed a cluster-based sampling approach to identify both the study areas and respondents. Two districts were selected based on their relatively higher concentration of beneficiaries under cluster-based demonstrations for the TRFA Scheme (pulses and oilseeds). Within each selected district, two villages were chosen, resulting in a total sample of 144 households (HH), as elaborately presented in the above flowchart. An important note: 4 sample villages are mentioned here, but we actually take data from 6 different mouzas (Aoyshberia, Kamlakantapur, Khanjanpur, Khordanahala, Kuchli, Simla).

The sample size was calculated using the infinite-population formula, which is appropriate for studies involving large, undefined populations.

2.3. Primary and Secondary Data Collection

This study utilized both primary and secondary data to ensure a comprehensive analysis. Primary data were collected through a digital survey administered via the Kobo Toolbox, focusing on key aspects such as the current status of rice fallow lands, the underlying reasons for non-cultivation prior to the TRFA period, and the perceived impact of existing Government policies and programmes.

Secondary data was sourced from official government repositories, including the Department of Agriculture and Farmers' Welfare. These datasets were used to contextualize and enrich the primary findings, offering a broader understanding of the study area and the challenges associated with rice fallow land utilization. The reference period spans two Separate agricultural years: 2015-16 (pre-TRFA implementation) and 2023-24 (the TRFA scheme is currently running), which enable a comparative assessment of changes over time.

2.4. Analytical Approach

To address the study's four objectives, a combination of geospatial analysis, statistical methods and policy evaluation techniques was used:

- Objective 1 and 2 (Remote Sensing and GIS): Satellite imagery and spatial analysis tools were used to map existing agricultural land use and land cover patterns, with a specific focus on identifying and explaining current rice fallow areas.
- Objective 3 (Farmer Perceptions and reasons for not cultivating rice fallow lands): Garret Ranking is used to capture the farmers' perceptions, and Chi-square tests are applied to uncover the reasons or determinants for not cultivating the rice fallows prior to the TRFA period.
- Objective 4 (Policy Evaluation): A "Before and After" analytical framework was adopted to evaluate the effectiveness of existing policies and programs, particularly the Targeted Rice Fallow Area (TRFA) scheme.
- Objective 5: Lastly, based on insights drawn from these four components, the study proposed targeted policy recommendations aimed at promoting sustainable agricultural practices in rice fallow regions.

2.5. Garrett Ranking Methodology

To analyze the perceptions of selected TRFA farmers regarding their decision not to cultivate rice fallow lands, the study employed the Garrett Ranking technique, which is a widely recognised statistical method for prioritising factors based on respondent feedback (Upadhyay et al., 2021). The Garrett score was calculated using the following formula:

$$\text{Percentposition} = \frac{100 \times (\mathrm{R_{ij}} - 0.5)}{\mathrm{N_j}}$$

The resulting percent position values were then converted into Garrett scores using a standardized conversion table. For each factor, the mean Garrett score was computed, and the factors were subsequently ranked in descending order of their mean scores. This enabled a clear understanding of the most influential reasons behind farmers' reluctance to cultivate rice fallow lands.

2.6. Chi-Square Test Methodology

To assess the influence of existing policies and programs on rice fallow land cultivation, the study employed the Chi-Square test, a nonparametric statistical method used to examine associations between categorical variables (Turhan, 2020). Specifically, the test was applied to explore the relationship between farmers' reasons for leaving rice fallow and their socio-economic characteristics under the TRFA scheme. The Chi-Square statistic was calculated using the formula:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where, χ^2 = Chi-Square statistic; O = Observed frequency; E = Expected frequency; Σ is the summation of the calculations for all cells in the contingency table.

The hypotheses tested were:

- Null Hypothesis (H_0): No significant association exists between the reasons for leaving rice fallow and the characteristics of the Targeted Rice Fallow Area (TRFA) Scheme's beneficiary farmers.
- Alternative Hypothesis (H_1): A significant association exists between these variables.

The calculated Chi-Square value was compared against the critical value from the Chi-Square distribution table, based on the degrees of freedom (*df*) and the chosen significance level (α). If the computed value exceeded the critical threshold, the null hypothesis was rejected, which indicates a statistically significant relationship. The test evaluated the impact of key factors, such as farm size, education level, and income level, on farmers' decisions to leave rice fallow. The results help to identify the most influential variables shaping cultivation behaviour in TRFA-designated sample villages, selected for this particular study.

2.7. Before and After Approach

To evaluate the effectiveness of existing agricultural policies and programmes (particularly the Targeting Rice Fallow Areas, i.e., TRFA scheme), the study adopted a "Before and After Approach" method (Turhan, 2020). Researchers conducted surveys of farmers participating in TRFA cluster-based demonstrations for pulses and oilseeds to capture the scheme's impact. This comparative approach assessed changes in the utilization of rice fallow lands, the extent of crop diversification, and variations in farm income before and after the implementation of TRFA. By doing so, the study can provide valuable insights into the policy outcomes and emphasize areas that need further improvement.

Chapter-3: Agricultural Land Use Dynamics and Paddy Cultivation Trends in West Bengal: A Spatial Analysis

3.1. Classification of Area-specific focus on Fallow land

The research titled "Rejuvenating Rice Fallow Land: An All-India Study Using Remote Sensing and GIS" includes a detailed state-level report for West Bengal, prepared by the Agro-Economic Research Centre (AERC), Visva-Bharati, Santiniketan. The state of West Bengal, located in eastern India, is characterized by a rich diversity of landscapes and agro-ecological conditions. As per the West Bengal State Agriculture Department, the state incorporates six distinct Agro-Climatic Zones[5]: i.e., the Eastern Himalayan Mountain Region; ii. The Terrain Zone; iii. The Old Alluvial Zone; iv. The Lateritic Zone; v. The Gangetic Alluvial Plains; vi. The Coastal Saline Zone along the northern part of the Bay of Bengal. West Bengal's coastline stretches approximately 392 kilometres (Paul et al.,2025), offering a blend of fertile deltaic soils and estuarine ecosystems. This ecological diversity plays a crucial role in shaping West Bengal's agricultural potential.

West Bengal remains a predominantly agrarian state. Although it accounts for just 2.7% of India's geographical area, it sustains nearly 8% of the national population. The state is home to approximately 71.23 lakh farm families, of which 96% are small and marginal farmers. The average landholding size is a modest 0.77 hectares, reflecting the fragmented nature of agricultural ownership. Despite these constraints, West Bengal benefits from diverse natural resources and varied agro-climatic zones, enabling the cultivation of a wide array of crops. The net cropped area stands at 52.05 lakh hectares, representing 68% of the state's geographical area and 92% of its arable land. The cropping intensity is remarkably high at 184%, indicating widespread multi-cropping practices[6] (Directorate of Bureau of Applied Economics & Statistics, 2015-16).

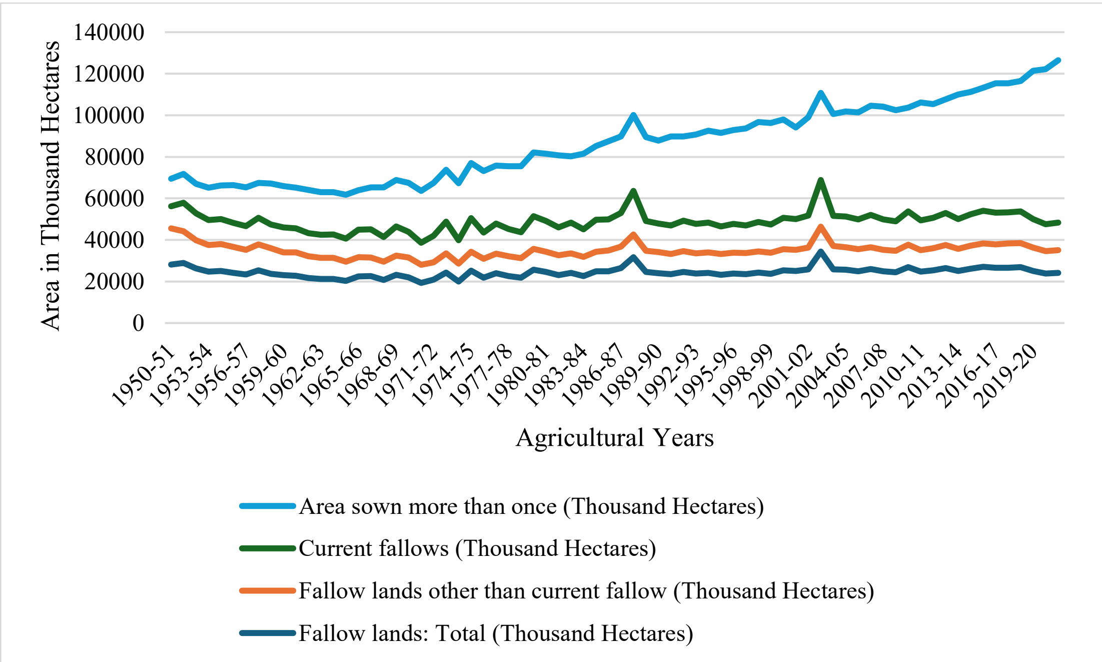
However, the state's location in the humid tropics, coupled with its proximity to the Bay of Bengal, makes it vulnerable to climatic hazards such as floods, cyclones, and hailstorms. Although West Bengal enjoys a surplus production of rice, vegetables, and potatoes, there remains a significant shortfall in the production of pulses, oilseeds, and maize, leading to a dependence on imports from other regions.

[5] https://farmech.dac.gov.in/Content/FarmerGuide/WB/1w.html
[6] Directorate of Bureau of Applied Economics & Statistics

Key challenges to agricultural growth include: Soil degradation due to imbalanced fertilizer use; Limited access to improved seed varieties; Low levels of farm mechanization; and fragmented, unorganised marketing systems. Addressing these issues is critical to enhancing productivity, ensuring food security and promoting sustainable agricultural development across the state[7] (Govt. of West Bengal, 2023). So, the study titled "Rejuvenating Rice Fallow Land: An All-India Study Using Remote Sensing and GIS" aims to assess rice fallow regions across West Bengal, with a specific focus on identifying agro-ecologically suitable zones for cultivating short-duration crops during the Rabi season.

3.1.1. Indian Scenario

The time-series data on land use patterns in India (Figure 3.1), spanning from 1950-51 to 2019-20, depict valuable insights into the dynamics of fallow land and the areas sown more than once. This analysis places particular emphasis on the trends observed over the past two decades. Between 2002-03 and 2019-20, the extent of fallow land in India declined significantly from 34.43 million hectares to 24.17 million hectares (Kumar et al., 2019; Meiyappan et al., 2016). This downward trend reflects a complex interplay of factors, including policy-driven initiatives to enhance agricultural productivity, expansion of cultivable land, and improved land management practices.



Source: Directorate of Economics & Statistics, MoA&FW

Figure 3.1: Agricultural Land Use Pattern of India (1950-51 to 2020-21)

The area under current fallow land is left uncultivated for a short period to restore soil fertility, which has declined markedly over the past two decades. It is seen that there were two boom years for

[7] https://wb.gov.in/departments-details.aspx?id=D170907140022669&page=Agriculture

current fallows, i.e., 1987-88 and 2002-03. But it declined from 22.46 million hectares in 2002-03 to 13.26 million hectares in 2019-20, reflecting a reduction of nearly 41 per cent in current fallows. This shift indicates that farmers are increasingly bringing previously rested land back into cultivation, likely driven by the growing pressure to boost food production and meet the demands of an expanding population. In contrast, the area classified as fallow land other than current fallow (typically land left uncultivated for longer durations) has remained relatively stable. Between 2005-06 and 2019-20, it fluctuated modestly from 10.70 million hectares to 11.65 million hectares, suggesting limited change in long-term land abandonment or rest practices in India.

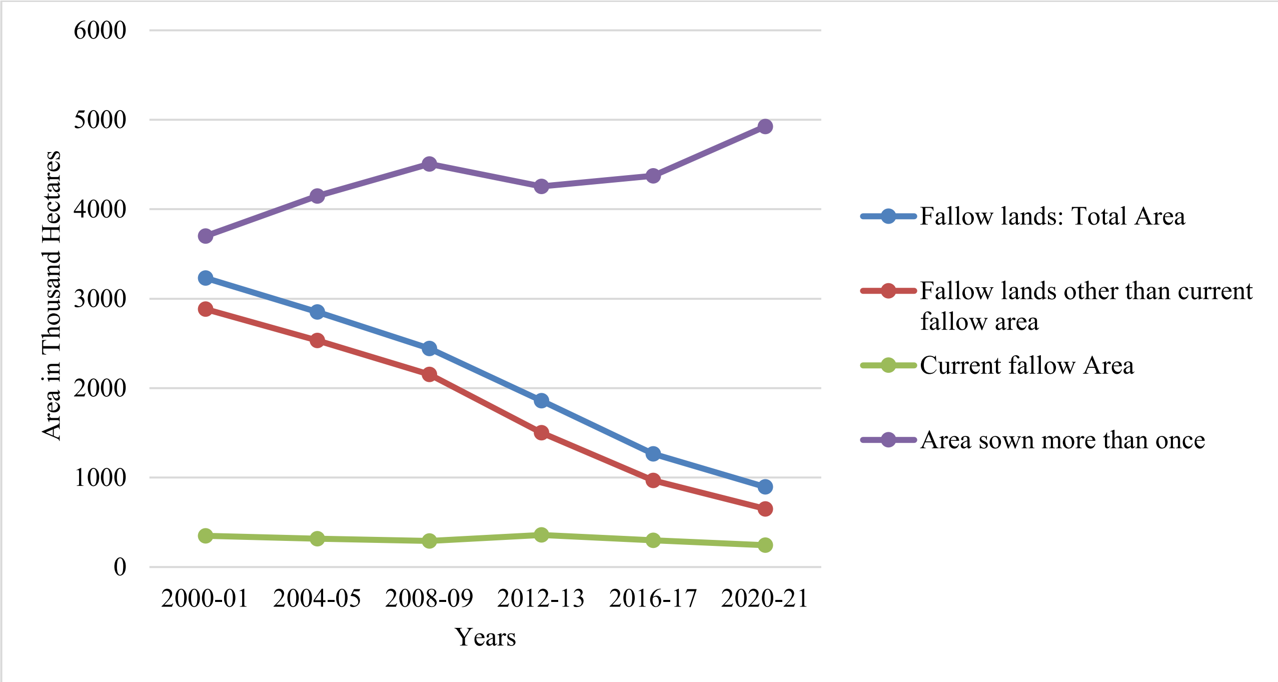
Apart from that, the data highlight a substantial rise in the area sown more than once, a vital indicator of cropping intensity. Between 2002-03 and 2019-20, this figure surged from 41.95 million hectares to 78.15 million hectares, marking an increase of over 86 percent. This upward trend reflects a strategic shift among farmers toward maximizing land productivity, likely facilitated by enhanced irrigation infrastructure; adoption of high-yielding and resilient crop varieties; and implementation of efficient agronomic practices. This kind of intensification aligns with broader efforts to meet rising food demand and optimize resource use (Meiyappan et al., 2016; Kumar et al., 2019; and Kumari & Badal, 2020).

The sharp rise in the area sown more than once can be attributed to multiple interlinked factors, notably the expansion of irrigation networks, the introduction of high-yielding crop varieties and the adoption of modern agricultural technologies (Kumar et al., 2019; Meiyappan et al., 2016). These developments have enabled farmers to intensify cropping cycles and make more productive use of available land.

The concurrent decline in current fallow land and increase in multi-cropped area signal a positive transformation in India's agricultural landscape. Together, these trends reflect a move toward more efficient land utilization, improved agricultural productivity and a heightened responsiveness to food security demands. Despite these encouraging patterns, it remains essential to examine the underlying drivers shaping land use dynamics. Factors such as climate variability, policy interventions and technological diffusion warrant closer scrutiny to build a delicate understanding of regional and national shifts (Mishra et al., 2020; Behera, 2020).

3.1.2. The Context of West Bengal

The following Figure 3.2 shows the agricultural land-use pattern in West Bengal, including total fallow area, fallow lands other than current fallow (FL-5 and FL-10), current fallow area (FL-1), and areas sown more than once, based on the unit of thousand hectares across quinquennial years. As shown in the figure, fallow lands other than current fallows and the current fallow area are gradually declining over the years (2001-2021), resulting in a decline in total fallow lands and an increase in areas sown more than once over the years.



Source: Directorate of Economics & Statistics, MoA&FW

Figure 3.2: Agricultural Land Use Pattern in West Bengal (2000-01 to 2020-21)

3.1.3. District-wise Status of Fallow Areas in West Bengal

Table 3.1 below is the depiction of rice fallow areas (in Hectares) of West Bengal across the years and districts, from 2020-21 to 2023-24[8]. It is seen that in 2020-21, Bankura district has the highest rice fallow areas (2.98 Lakh Ha), followed by Purulia (2.91 Lakh Ha), Purba Barddhaman (2.74 Lakh Ha) and Paschim Medinipur (2.47 Lakh Ha). Whereas, in the same year, Kolkata recorded the lowest rice fallow lands (0.00037 Lakh Ha), followed by Kalimpong (0.00124 Lakh Ha), Darjeeling (0.06343 Lakh Ha) and Alipurduar (0.06574 Lakh Ha). It probably happened due to the smaller demographic area and agricultural land in these districts. Looking at the moderate class of districts having rice fallow land, it is found that Paschim Barddhaman leads the table (0.64 Lakh Ha), followed by Murshidabad (0.61 Lakh Ha), North-24 Parganas (0.50 Lakh Ha), Howrah (0.31 Lakh Ha) and Uttar Dinajpur (0.28 Lakh Ha).

But a contrasting picture emerges when we turn our eyes to 2023-24. It is evident that rice fallow is lower than in 2020-21. Conversely, rice fallow land increased in Purba Barddhaman (2.82 Lakh Ha) and Paschim Medinipur (2.56 Lakh Ha). In the lower segment, Kolkata is still in the first position,

[8] Source: ADRTC, Bengaluru (KSRSAC and ISRO)

and the rice fallow area has been reduced the most (0.00022 Lakh Ha) in 2023-24. Whereas, rice fallow land increased in Darjeeling (0.08156 Lakh Ha), Alipurduar (0.12417 Lakh Ha) and Kalimpong (0.00364 Lakh Ha). In the table below, the moderate-class districts again show a contrast. In 2023-24, the rice fallow area has decreased most in Murshidabad (0.43 Lakh Ha), followed by Paschim Barddhaman (0.48 Lakh Ha), North 24-Parganas (0.38 Lakh Ha), and Howrah (0.27 Lakh Ha). Whereas, only in Uttar Dinajpur did rice fallow land increase (0.49 Lakh Ha) in 2023-24 compared to 2020-21.

Table 3.1: Rice Fallow Area of West Bengal (In Hectares) 2020-2024

DISTRICTS/YEARS	2020-21	2021-22	2022-23	2023-24	DISTRICTS/YEARS	2020-21	2021-22	2022-23	2023-24
ALIPURDUAR	6574	7102	15013	12417	PURBA BARDDHAMAN	273859	199616	293855	281933
BIRBHUM	152377	89784	188959	135891	PURBA MEDINIPUR	143797	42548	141943	133408
DAKSHIN DINAJPUR	27558	17601	44700	30440	HOWRAH	30821	8355	34722	27039
DARJEELING	6343	3357	11065	8156	HOOGHLY	125642	69239	146494	118394
JALPAIGURI	18163	9534	30842	23874	KOLKATA	37	20	56	22
COOCH BEHAR	33216	14008	41782	25693	NORTH 24-PARGANAS	49970	28622	50688	38097
MALDAH	21746	20037	29791	16645	PASCHIM MEDINIPUR	246628	121272	271657	255548
MURSHIDABAD	61026	32248	59796	42849	PURULIA	290650	155318	292418	197841
NADIA	17549	4798	11997	8293	SOUTH 24-PARGANAS	160492	59730	177517	158284
UTTAR DINAJPUR	27504	27140	49146	31255	JHARGRAM	117290	80349	124611	104397
KALIMPONG	124	137	434	364	PASCHIM BARDDHAMAN	64041	44523	62993	47513
BANKURA	297623	210337	304784	253540	TOTAL AREA (W.B)	2173029	1245673	2385264	1951892
Source: ADRTC, Bengaluru (KSRSAC and ISRO)									

Table 3.2: Percentage Change in Rice Fallow Land from 2020-21 to 2023-24

Districts	Change (in %)	Rank	Districts	Change (in %)	Rank
NADIA	-52.74	1	BIRBHUM	-10.82	12
KOLKATA	-40.60	2	PURBA MEDINIPUR	-7.22	13
PURULIA	-31.93	3	HOOGHLY	-5.77	14
MURSHIDABAD	-29.79	4	SOUTH 24-PARGANAS	-1.38	15
PASCHIM BARDDHAMAN	-25.81	5	PURBA BARDDHAMAN	2.95	16
NORTH 24-PARGANAS	-23.76	6	PASHCHIM MEDINIPUR	3.62	17
MALDAH	-23.46	7	DAKSHIN DINAJPUR	10.46	18
COOCHBEHAR	-22.65	8	UTTAR DINAJPUR	13.64	19
BANKURA	-14.81	9	DARJEELING	28.58	20
HOWRAH	-12.27	10	JALPAIGURI	31.45	21
JHARGRAM	-10.99	11	ALIPURDUAR	88.89	22
Sources: ADRTC, Bengaluru and Author’s Calculation			KALIMPONG	194.42	23

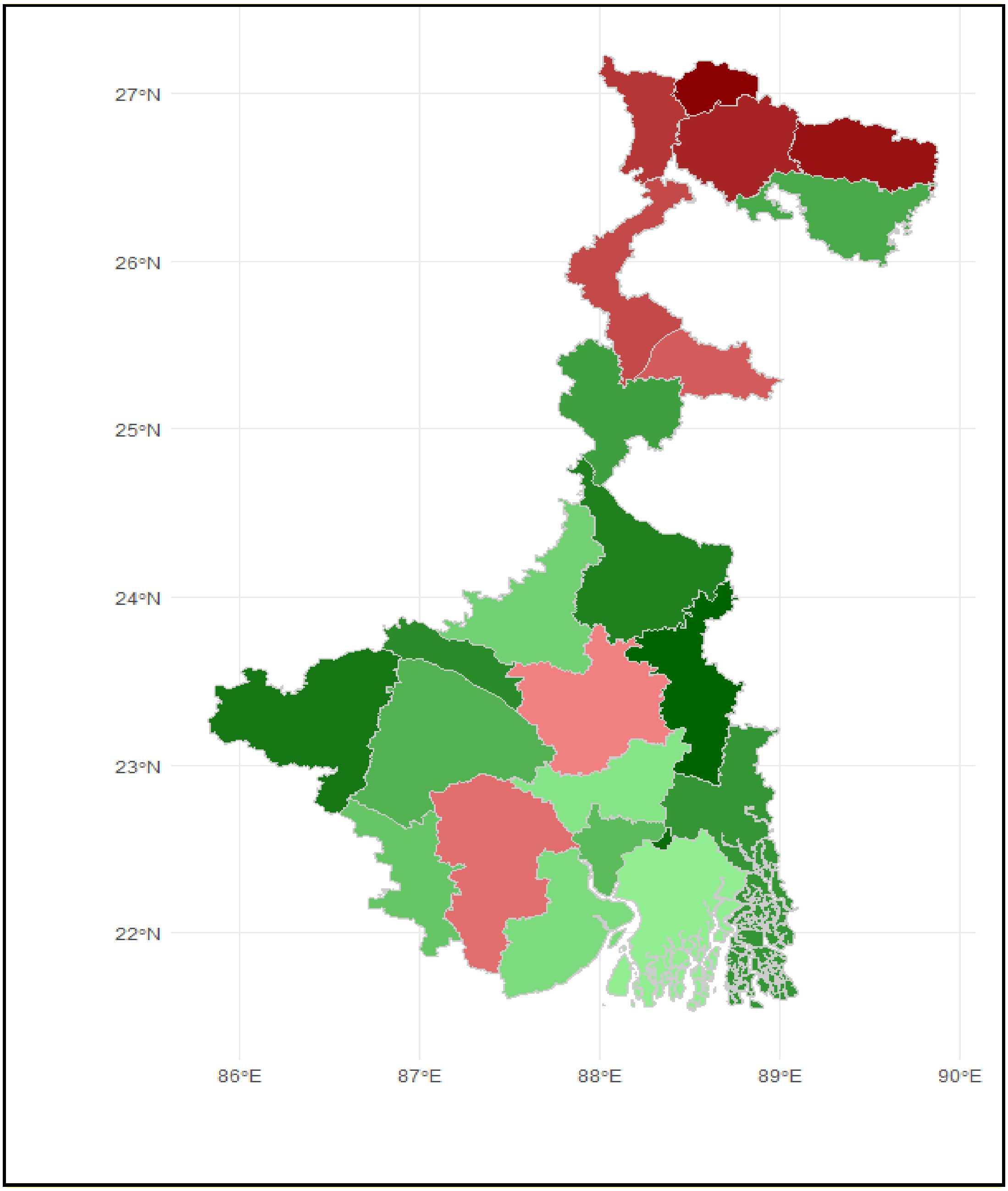
Therefore, it is important to calculate the percentage change over these four years, or over one quinquennium, as year-to-year fluctuations are present. Table 3.2 is nothing but a calculation to catch the district-wise percentage changes of rice fallow area, and a simple formula used here is {(Rice Fallow Area in 2023-24 – Rice Fallow Area in 2020-21)/ Rice Fallow Area in 2020-21*100}, i.e., the latest change in rice fallow land taking 2020-21 as the base year. After that, all districts are ranked by the value of changes in rice-fallow land over the four-year period in West Bengal.

In Table 3.2, given above, it is observed that the change, i.e., reduction in rice fallow land, is extensive in Nadia (-52.74%), followed by Kolkata (-40.60%), Purulia (-31.93%), Murshidabad (-29.79%), Paschim Barddhaman (-25.81%) and North 24-Parganas (-23.76%). So, it indicates that, in terms of rice fallow land reduction, all the negative values, i.e., up to the South 24 Parganas district (Ranked 15). However, an increase in rice fallow land is observed in the remaining eight districts, with positive values; among them, Kalimpong (194.42%) shows the highest increase in rice fallow area (ranked 22), and Purba Barddhaman shows the lowest increase (2.95%).

Here, a map is also constructed showing the percentage change in rice fallow lands district-wise from 2020-21 to 2023-24 (Figure 3.3). Here we used the basic two colours, Green and Red, but there are also some sub-colours (under Green: Deepest to Lightest, where the minus values exist, and under Red: Lightest to Deepest, with plus values, as per Table 3.2). Deeper Greens indicate where changes in rice fallow lands are decreased (like districts: Nadia, Kolkata, Purulia, Murshidabad, Paschim Barddhaman, North 24-Parganas, etc.), and Deeper Reds specify that changes in rice fallow lands are increased (like districts: Kalimpong, Alipurduar, Jalpaiguri, Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, etc.). So, the deeper-to-deepest green shows the reduction (15 districts with negative values), and the deeper-to-deepest red shows the expansion (8 districts with positive values) of rice fallow lands in West Bengal.

Apart from that, a GIS map is also prepared based on data of district-wise current fallow areas (see appendix; Table-A1) given below in Figure 3.4, where it is seen that deep red coloured districts like Purulia, Bankura, and Maldah have 113232 Ha., 62144 Ha., 58200 Ha. of current fallow land (FL-1), respectively, in 2000-01. But, the current fallows of Purulia and Maldah declined to 97294 Ha., 49634 Ha., respectively, in 2020-21; that is why both the districts remained with the same colour, whereas Bankura's current fallows dropped to 18254 Ha. in 2020-21, changing the colour from deep red to orange. This has happened because most of the current fallow lands in Bankura were brought into cultivation in 2020-21, compared to 2000-01. Actually, the map also shows deep red to lighter yellow, while deep red remains deep red; i.e., the amount of current fallow land does not change significantly in 2020-21 compared to 2000-01, as in Purulia and Maldah districts. Dinajpur Uttar changed its colour from orange to yellow, indicating that the current fallow area declined from 4755

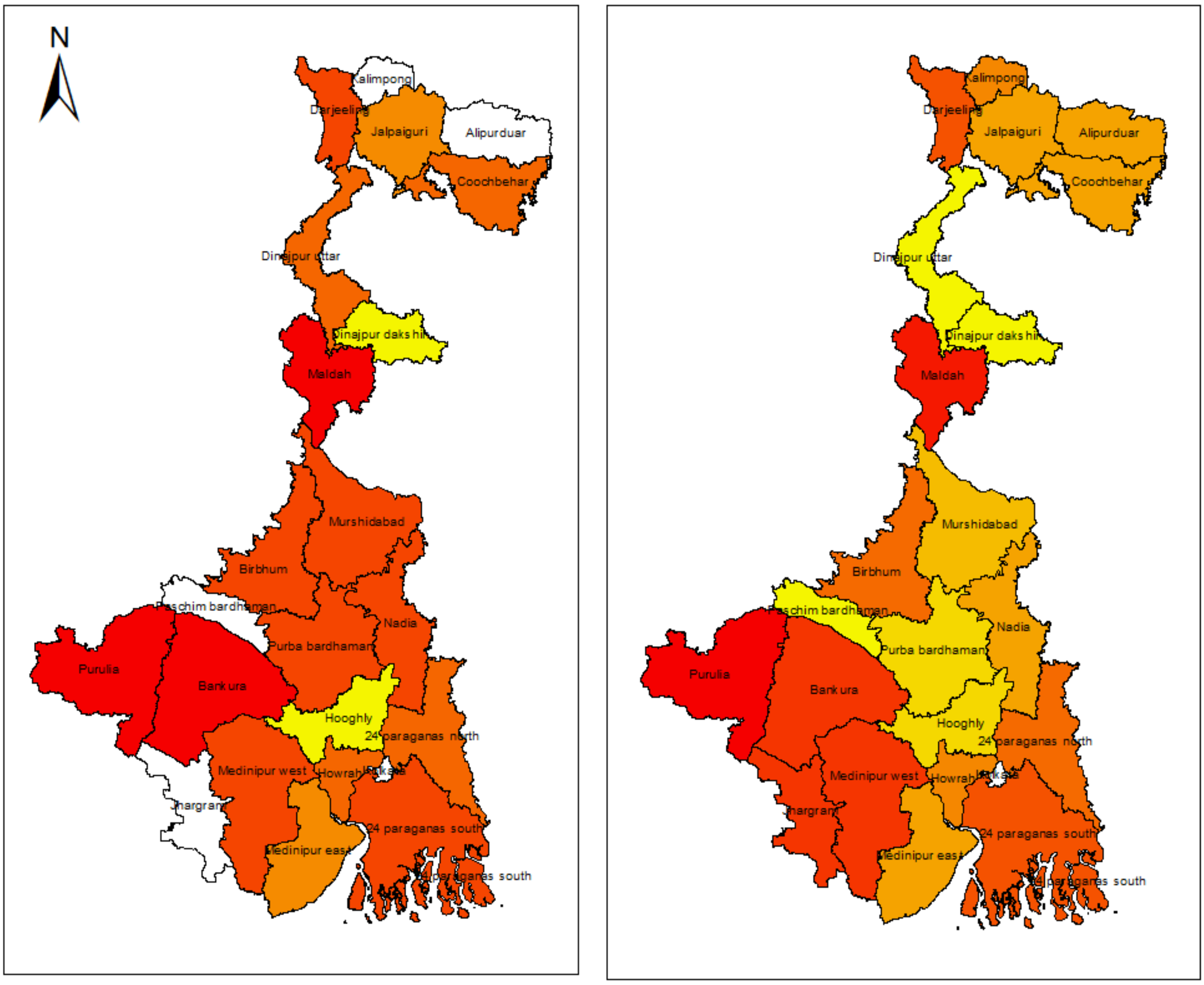
Ha. to 158 Ha. over the period 2000-01 to 2020-21. Here, it is noticeable that the districts of Alipurduar, Kalimpong, Jhargram, and Paschim Bardhaman were formed on 25th June, 2014; 14th February, 2017; 4th April, 2017; and 7th April, 2017, respectively. Therefore, in GIS mapping, the data were unavailable (white-coloured) in 2000-01. But these were available for 2020-21, showing different colours, such as orange or yellow, based on the intensity of the current fallow land. It is also important to mention here, amount of current fallow lands significantly decreases in Purba Bardhaman (9772 Ha. to 505 Ha.), Dakshin Dinajpur (1487 Ha. to 89 Ha.), and Murshidabad (20567 Ha. to 783 Ha.); while only Nadia remains almost with same colour, i.e., orange to deep yellow, as the data shows very little amount of current fallow it was 2000-01 (768 Ha.) and lastly, in 2020-21 (407 Ha.).



Sources: ADRTC, Bengaluru and Author's Calculation

Figure 3.3: Mapping of Percentage Change in Rice Fallow Land from 2020-21 to 2023-24

Therefore, it is evident from Figure 3.3 that there is a significant footprint (as per the sources involved) of district-wise expansion as well as a reduction in rice fallow areas in West Bengal in 2023-24 compared to 2020-21.



Sources: DA&FW, MoA&FW and Author's Calculation

Figure 3.4: Mapping of Change in Current Rice Fallow Land from 2000-01 to 2020-21

3.1.4. District-wise Status of Paddy Area in West Bengal

Table 3.3 below is a reflection of the paddy area in West Bengal in hectares (Ha.) from 2020-21 to 2023-24 that depicts a pattern of fluctuation that reflects regional (district-level) disparities in cultivation, possibly due to climatic variability. At the state level, the total paddy area was 3,270,496 Ha. in 2020-21, which declined sharply to 2,540,662 Ha. in 2021-22. A recovery was recorded in 2022-23, when the area expanded to 3,359,799 hectares, before contracting again to 2,880,340 hectares in 2023-24. These fluctuations indicate the strong dependence of paddy cultivation on rainfall distribution, irrigation facilities, and other external factors, such as socio-economic conditions.

District-level data represent the irregular distribution of paddy cultivation across the state. Purba Barddhaman, Paschim Medinipur, Bankura, and Purulia consistently reported the largest areas under paddy (each exceeding 300,000 hectares in peak years), making them the leading contributors to the state's production. Birbhum, Hooghly, South 24 Parganas, and Murshidabad also contributed significantly, though their figures fluctuated over the years. On the other hand, districts like Darjeeling, Kalimpong, and Kolkata recorded very small areas, often below 15,000 hectares, reflecting limitations of the agro-climatic zone (for Darjeeling and Kalimpong, as these two districts fall under the northern hilly area) and urban land-use patterns (for Kolkata).

The decline in 2021-22 was widespread, with sharp reductions in districts like Birbhum, Purulia, and Murshidabad, signifying the impact of erratic rainfall patterns in the monsoon or reduced input support. The rebound in 2022-23 was particularly strong in Bankura, which reached 367,469 hectares, and Purulia, which reported 319,735 hectares. However, the subsequent decline in 2023-24 again pointed to challenges in sustaining cultivation, with Bankura falling to 313,366 hectares and Purulia to 255,324 hectares. Urban districts such as Kolkata and Howrah consistently reported low figures, as we mentioned earlier, underscoring the dominance of non-agricultural land use.

Overall, the data indicate that while West Bengal remains a major paddy-growing state, the cultivation area is highly vulnerable to climatic conditions and infrastructural constraints. Districts with better irrigation coverage, such as Barddhaman and both the Paschim and Purba Medinipur, show relatively stable trends, whereas rainfed regions like Purulia and Bankura exhibit greater fluctuations.

Table 3.3: Paddy Area of West Bengal (In Hectares), 2020-2024

Districts/Years	2020-2021	2021-2022	2022-2023	2023-2024	Districts/Years	2020-2021	2021-2022	2022-2023	2023-2024
ALIPURDUAR	25294	21110	30333	26267	PURBA BARDDHAMAN	387979	349988	396282	365075
BIRBHUM	222343	126877	239240	169913	PURBA MEDINIPUR	175167	165312	184777	165458
DAKSHIN DINAJPUR	95918	46597	102035	87255	HOWRAH	40906	31011	43910	34436
DARJEELING	10651	5410	14462	10915	HOOGHLY	183550	169177	188838	165876
JALPAIGURI	53936	27545	57822	54994	KOLKATA	321	345	340	282
COOCH BEHAR	95216	46530	82569	78376	NORTH 24-PARGANAS	118882	109895	125618	93389
MALDAH	88183	57841	97571	86040	PASCHIM MEDINIPUR	347000	318872	364316	324911
MURSHIDABAD	141564	79291	126493	107241	PURULIA	313879	201199	319735	255324
NADIA	60226	34688	52992	52188	SOUTH 24-PARGANAS	223642	179399	237050	192512
UTTAR DINAJPUR	109069	84458	112586	109928	JHARGRAM	139129	116866	143982	128109
KALIMPONG	168	193	520	406	PASCHIM BARDDHAMAN	72611	62096	70861	58080
BANKURA	364862	305962	367469	313366	TOTAL AREA (W.B)	3270496	2540662	3359799	2880340

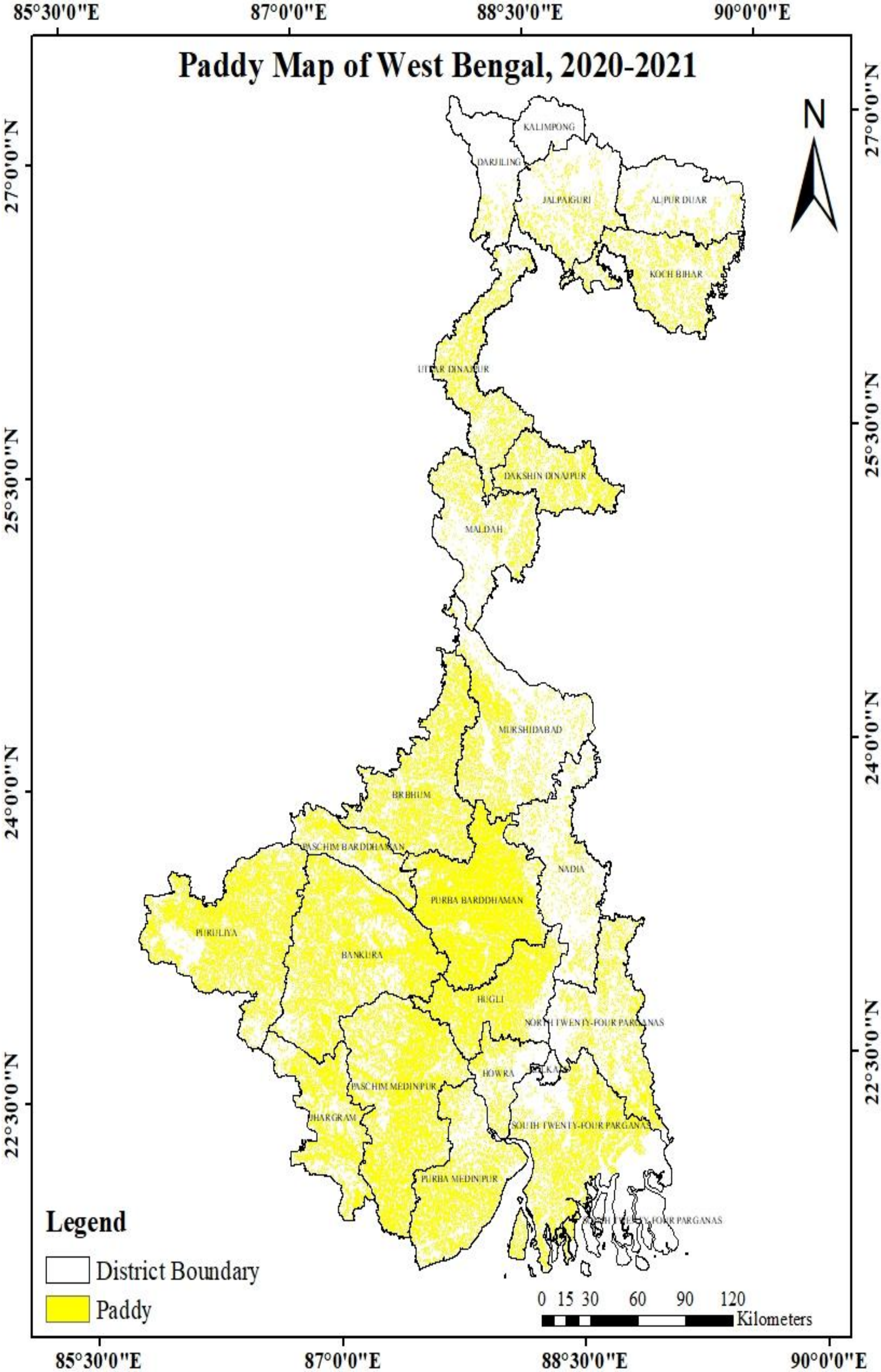
Source: ADRTC, Bengaluru (KSRSAC and ISRO)

The findings from the above table highlight the importance of strengthening climate resilience, improving irrigation infrastructure, and ensuring input support to stabilize paddy cultivation across the state.

Table 3.4: Percentage Change in Paddy Area from 2020-21 to 2023-24

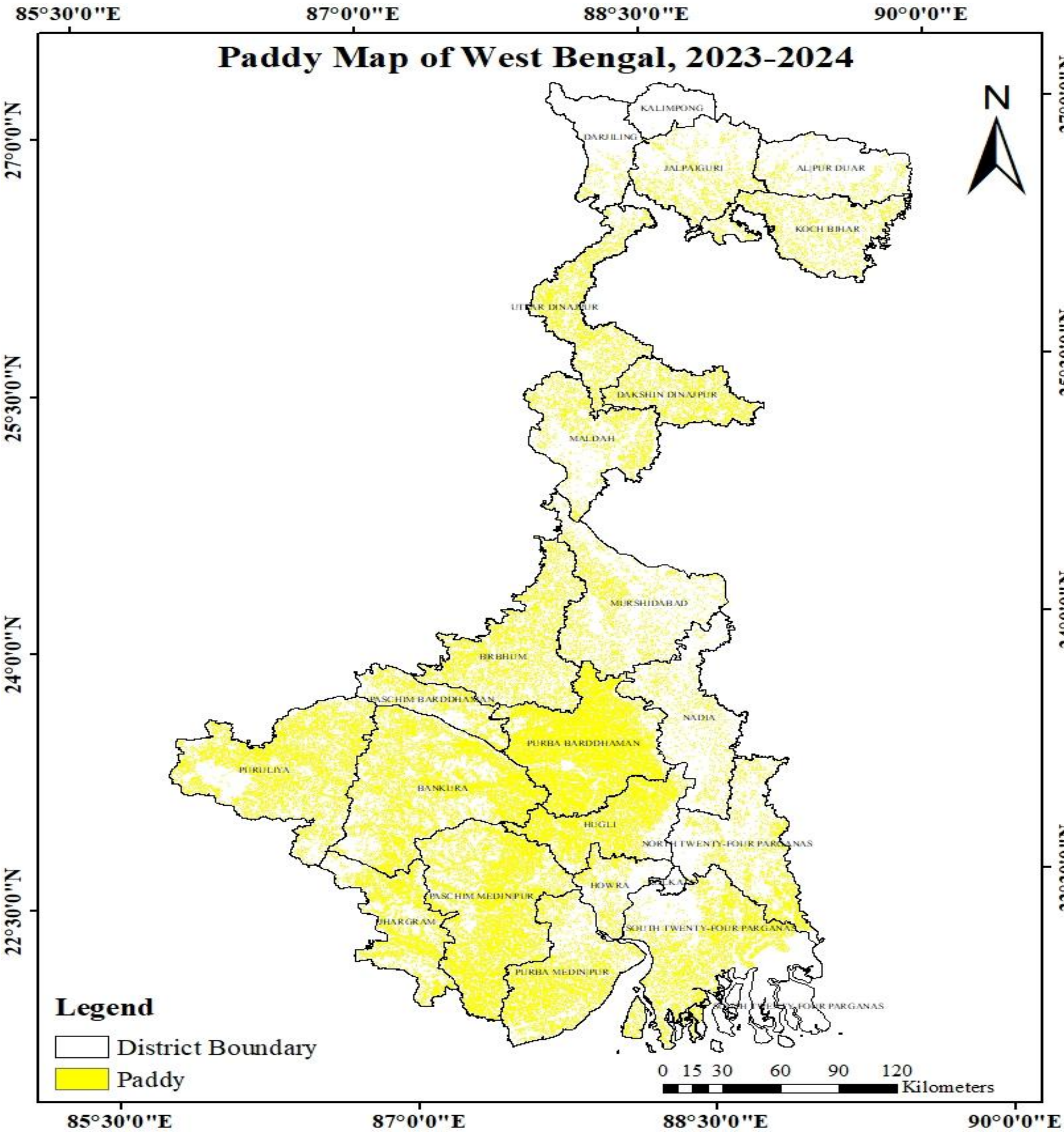
Districts	Change (in %)	Rank	Districts	Change (in %)	Rank
MURSHIDABAD	-24.25	1	HOOGHLY	-9.63	12
BIRBHUM	-23.58	2	DAKSHIN DINAJPUR	-9.03	13
NORTH 24-PARGANAS	-21.44	3	JHARGRAM	-7.92	14
PASCHIM BARDDHAMAN	-20.01	4	PASCHIM MEDINIPUR	-6.37	15
PURULIA	-18.66	5	PURBA BARDDHAMAN	-5.90	16
COOCH BEHAR	-17.69	6	PURBA MEDINIPUR	-5.54	17
HOWRAH	-15.82	7	MALDAH	-2.43	18
BANKURA	-14.11	8	UTTAR DINAJPUR	0.79	19
SOUTH 24-PARGANAS	-13.92	9	JALPAIGURI	1.96	20
NADIA	-13.35	10	DARJEELING	2.48	21
KOLKATA	-12.23	11	ALIPURDUAR	3.85	22
Sources: ADRTC, Bengaluru and Author's Calculation			KALIMPONG	141.99	23

The above Table 3.4 reflects the total percentage change in paddy area over the period 2020-21 to 2023-24. The yearly fluctuations are already shown in Table 3.3; hence, this table presents the overall percentage change using the same formula as in Table 3.2, along with ranking. Ultimately, the table reveals a prominent pattern of decline (2020-21 to 2023-24) of paddy area across most districts, with a few exceptions. Murshidabad, Birbhum, and North 24-Parganas experienced the sharpest shrinkages, with reductions of over 20 percent, signifying substantial shifts away from traditional paddy cultivation. Other districts, such as Paschim Barddhaman, Purulia, and Cooch Behar, have also recorded notable decreases, indicating extensive structural changes in cropping patterns, possibly driven by water scarcity, rising input costs, or diversification into alternative crops. Moderate declines are observed in districts such as Howrah, Bankura, and South 24-Parganas, whereas even core rice-producing areas, such as Purba Barddhaman and Purba Medinipur, recorded smaller but still negative changes. In contrast, northern districts, including Jalpaiguri, Darjeeling, and Alipurduar, show modest increases, suggesting localised resilience or expansion. The most remarkable case is Kalimpong, which recorded an extraordinary growth of nearly 142 per cent, highlighting a dramatic shift in cultivation practices in this hill district, which was carved out of the Darjeeling district in 2017. Overall, the data highlight a significant reduction in paddy area in West Bengal, with regional disparities that call for district-specific policy responses. The decline in traditional rice belts or zones raises worries for food security and farmers' livelihoods.



Source: ADRTC, Bengaluru

Figure 3.5: Mapping Paddy Area in 2020-21



Source: ADRTC, Bengaluru

Figure 3.6: Mapping Paddy Area in 2023-24

Figures 3.5 and Figure 3.6 are nothing but a mapping of the above-written changes in paddy area across the existing districts of West Bengal, where deeper yellow shows that the paddy area has increased, while lighter yellow reflects that the paddy area has decreased in Figure 3.6 (for 2023-24) compared to Figure 3.5 (2020-21), but at a slower pace. In Table 3.4, it is seen that from Murshidabad to Maldah, the paddy area has decreased in several districts, with negative values, while the colour of the red starts in Uttar Dinajpur and reaches its deepest hue at Kalimpong (Figure 3.5).

Table 3.5 below shows the district-wise change in rice production in West Bengal in the period of 2000-01 to 2022-23, where it is seen that rice production of Hooghly has increased the most, i.e., 313130 tonnes (62.17%), followed by Cooch Behar (59.42%) and Dakshin Dinajpur (46.79%).

3.1.5. District-wise Status of Rice Production in West Bengal

This section is trying to depict the district-wise status of rice production in West Bengal, where it is seen in Table 3.5 that Hooghly has recorded the maximum increase in rice production, i.e., from 503703 tonnes to 816833 tonnes (62.17%) in the period of 2000-01 to 2022-23, followed by Cooch Behar (59.42%) and Dakshin Dinajpur (46.79%). It is also evident from the table that rice production decreased only in Nadia (-2.43%) and Jalpaiguri (-5.53%) during the same period. It is also important to mention here that the calculations for Jhargram, Alipurduar, Paschim Bardhaman, and Kalimpong cannot be applied, as these districts were not formed in 2000-01. But we can see the production amount in Table 3.5 for the year 2022-23. Another crucial point to note: Tables 3.5, 3.6, and 3.7 all give ranks based on percentage change (% change in the Tables).

Table 3.5: District-Wise Change of Rice Production in West Bengal (2000-01 to 2022-23)

Districts	2000-01	2022-2023	Change in Rice Production (in Tonnes)	% change	Rank
HOOGHLY	503703	816833	313130	62.17	1
COOCH BEHAR	517283	824634	307351	59.42	2
DAKSHIN DINAJPUR	467351	686046	218695	46.79	3
PASCHIM MEDINIPUR	1344253	1970165	625912	46.56	4
SOUTH 24 PARAGANAS	866930	1214730	347800	40.12	5
PURULIA	474984	592602	117618	24.76	6
MURSHIDABAD	548177	682619	134442	24.53	7
DARJEELING	52893	65136	12243	23.15	8
MALDAH	523071	633851	110780	21.18	9
HOWRAH	224199	260740	36541	16.30	10
NORTH 24 PARAGANAS	640955	723468	82513	12.87	11
UTTAR DINAJPUR	628607	706768	78161	12.43	12
BIRBHUM	796496	868762	72266	9.07	13
PURBA BARDHAMAN	1571395	1698091	126696	8.06	14
BANKURA	993409	1050757	57348	5.77	15
PURBA MEDINIPUR	1240198	1244062	3864	0.31	16
NADIA	649997	634213	-15784	-2.43	17
JALPAIGURI	384137	362896	-21241	-5.53	18
JHARGRAM	0	503728	NA	NA	NA
ALIPURDUAR	0	238197	NA	NA	NA
PASCHIM BARDHAMAN	0	55067	NA	NA	NA
KALIMPONG	0	7917	NA	NA	NA

NA= Not Applicable

Sources: DA&FW, MoA&FW and Author's Calculation

3.1.6. District-wise Status of Paddy Area in West Bengal

From the table mentioned in Table 3.6, it is evident that only for the first three districts, i.e., Hooghly, Paschim Medinipur and Dakshin Dinajpur, a positive change in paddy area was recorded. In Hooghly, the paddy area increased by 47494 hectares (23.83%) from 2000-01 to 2022-23, followed by Paschim Medinipur (2.88%) and Dakshin Dinajpur (2.52%). Thereafter, the paddy area has decreased during the same period, starting from South 24 Parganas to Jalpaiguri. Paddy area decreased mostly in Jalpaiguri (-48.45%), possibly due to the segregation of Alipurduar from its district demography. Paddy area also significantly declined in Purba Medinipur (-25.37%) and Darjeeling (-21.00%). Here, for districts like Jhargram, Paschim Bardhaman, Alipurduar, and Kalimpong, the specific change cannot be captured, as these districts were established after 2000-01.

Table 3.6: District-Wise Change of Paddy Area in West Bengal (2000-01 to 2022-23)

Districts	2000-01	2022-23	Change in Paddy Area (in Ha.)	% Change	Rank
HOOGHLY	199299	246793	47494	23.83	1
PASCHIM MEDINIPUR	580253	596968	16715	2.88	2
DAKSHIN DINAJPUR	210737	216057	5320	2.52	3
SOUTH 24 PARAGANAS	425861	425188	-673	-0.16	4
MURSHIDABAD	224117	218082	-6035	-2.69	5
PURULIA	262186	248871	-13315	-5.08	6
PURBA BARDHAMAN	582654	538441	-44213	-7.59	7
COOCH BEHAR	291897	265678	-26219	-8.98	8
BANKURA	395569	355532	-40037	-10.12	9
MALDAH	221662	195088	-26574	-11.99	10
UTTAR DINAJPUR	283209	246710	-36499	-12.89	11
NADIA	229187	196045	-33142	-14.46	12
BIRBHUM	318185	269209	-48976	-15.39	13
NORTH 24 PARAGANAS	273954	222381	-51573	-18.83	14
HOWRAH	113268	91854	-21414	-18.91	15
DARJEELING	34141	26971	-7170	-21.00	16
PURBA MEDINIPUR	528299	394278	-134021	-25.37	17
JALPAIGURI	260845	134471	-126374	-48.45	18
JHARGRAM	0	177645	NA	NA	NA
ALIPURDUAR	0	99262	NA	NA	NA
PASCHIM BARDHAMAN	0	18895	NA	NA	NA
KALIMPONG	0	4754	NA	NA	NA

NA = Not Applicable

Sources: DA&FW, MoA&FW and Author's Calculation

3.1.7. District-wise Status of Rice Yield in West Bengal

Following the same approach, Table 3.7 attempts to capture district-wise changes in rice yield over two decades, i.e., 2000-01 to 2022-23. The following table depicts that the percentage increase is highest for Jalpaiguri (83.67%), i.e., from 1.47 in 2000-01 to 2.7 in 2022-23, followed by a significant increase in Cooch Behar (75.14%). Darjeeling also recorded a prominent increase in rice yield (56.13%). Afterwards, a moderate increase in Howrah, Dakshin Dinajpur, Paschim Medinipur, and South 24 Parganas was realized (43.43%, 43.24%, 42.24% and 40.20%, respectively). The remaining districts are also showing an increasing pattern, as mentioned in Table 3.7. It is possibly happening because the districts belong to six different agro-climatic zones with different soil types.

Table 3.7: District-Wise Change of Rice Yield in West Bengal ((2000-01 to 2022-23)

Districts	2000-01	2022-23	Change in Rice Yield (Tonnes/Ha.)	% change	Rank
JALPAIGURI	1.47	2.7	1.23	83.67	1
COOCH BEHAR	1.77	3.1	1.33	75.14	2
DARJEELING	1.55	2.42	0.87	56.13	3
HOWRAH	1.98	2.84	0.86	43.43	4
DAKSHIN DINAJPUR	2.22	3.18	0.96	43.24	5
PASCHIM MEDINIPUR	2.32	3.3	0.98	42.24	6
SOUTH 24 PARAGANAS	2.04	2.86	0.82	40.20	7
NORTH 24 PARAGANAS	2.34	3.25	0.91	38.89	8
MALDAH	2.36	3.25	0.89	37.71	9
PURBA MEDINIPUR	2.35	3.16	0.81	34.47	10
PURULIA	1.81	2.38	0.57	31.49	11
HOOGHLY	2.53	3.31	0.78	30.83	12
BIRBHUM	2.5	3.23	0.73	29.20	13
UTTAR DINAJPUR	2.22	2.86	0.64	28.83	14
MURSHIDABAD	2.45	3.13	0.68	27.76	15
BANKURA	2.51	2.96	0.45	17.93	16
PURBA BARDHAMAN	2.7	3.15	0.45	16.67	17
NADIA	2.84	3.24	0.4	14.08	18
PASCHIM BARDHAMAN	0	2.91	NA	NA	NA
JHARGRAM	0	2.84	NA	NA	NA
ALIPURDUAR	0	2.4	NA	NA	NA
KALIMPONG	0	1.67	NA	NA	NA

NA = Not Applicable

Sources: DA&FW, MoA&FW and Author's Calculation

So, as a whole, this chapter attempts to capture agricultural land-use dynamics, with a special focus on the trend of fallow lands in the context of India and West Bengal. Also, showed the district-wise changes in Paddy area, Rice Production, and Rice Yield, with explanations.

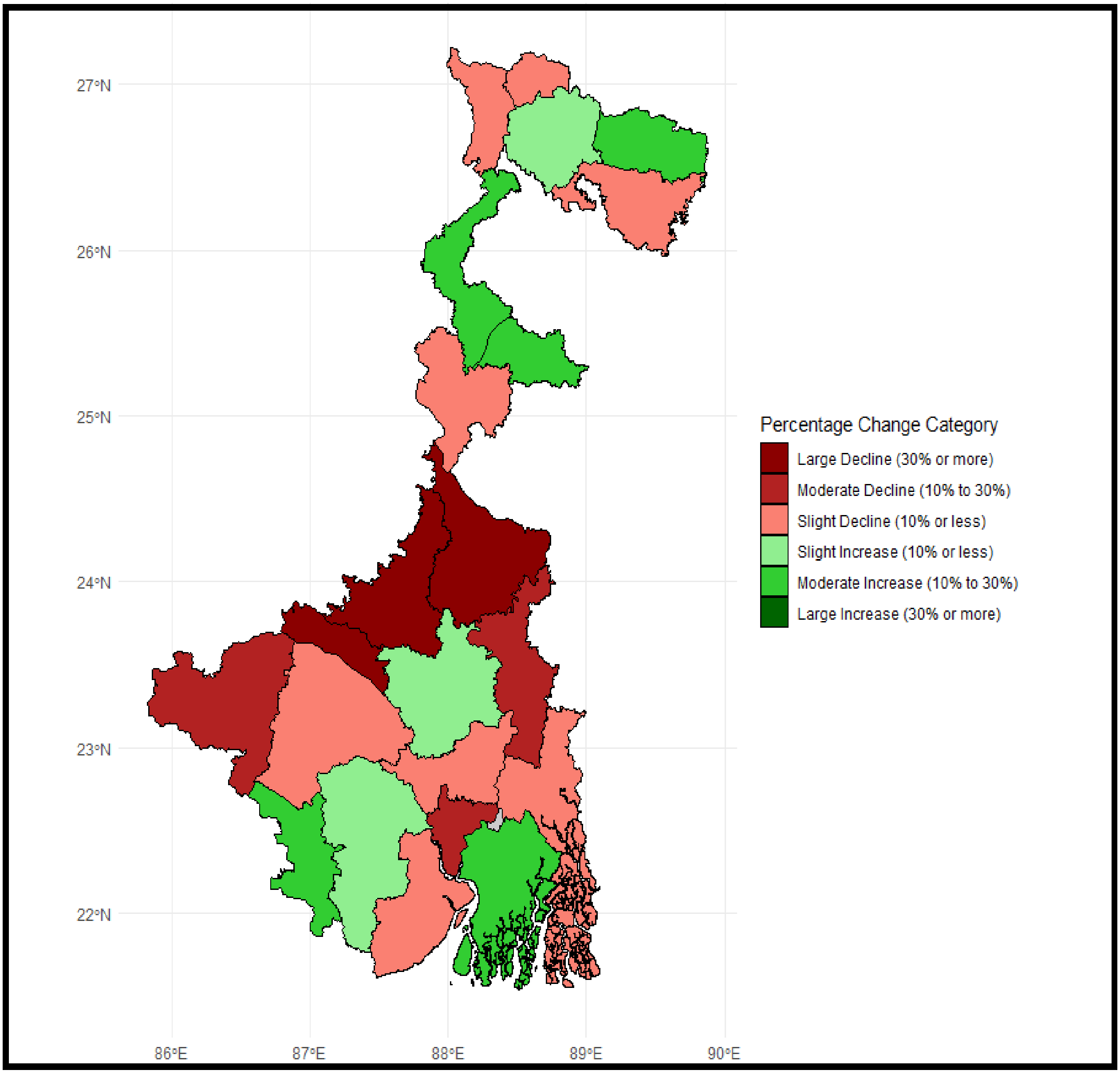
Chapter-4: Mapping and Analyzing Paddy Area, Rice Production and Yield in West Bengal

4.1. Mapping and Analyzing Paddy Area in West Bengal

This map shows the percentage change in paddy cultivation area across West Bengal's districts, comparing the reference years 2016-17 and 2022-23. This period is chosen because the TRFA implementation began in 2016-17. Each district is colour-coded to represent the direction and magnitude of change in paddy area, helping visualise spatial patterns of agricultural expansion or contraction. As per the legends on the map, a substantial decline (30% or more) in paddy areas is observed in districts such as Paschim Barddhaman, Birbhum, and Murshidabad. In Paschim Bardhaman, the reduction reflects a structural shift away from paddy towards other crops and land uses, driven by industrial expansion and declining irrigation reliability. Birbhum shows a similar pattern, with farmers increasingly diversifying into non-paddy crops due to soil and water constraints, leading to a sharp decline in paddy acreage. Murshidabad, traditionally a major rice-growing district, has also experienced a steep decline, largely due to groundwater stress, changing rainfall patterns, and a shift towards alternative crops such as maize and vegetables. These districts, shaded in the darkest red, highlight the most critical zones of shrinkage in West Bengal's paddy landscape.

Purulia, Nadia, and Howrah have evidenced a moderate decline (10% to 30%) in paddy area, while districts like Purba Barddhaman, Purba Medinipur, Hooghly, North 24-Parganas in the southern belt and Maldah, Cooch Behar, Darjeeling, and Kalimpong have recorded a slight fall in paddy area (10% or less), shaded by the lightest red.

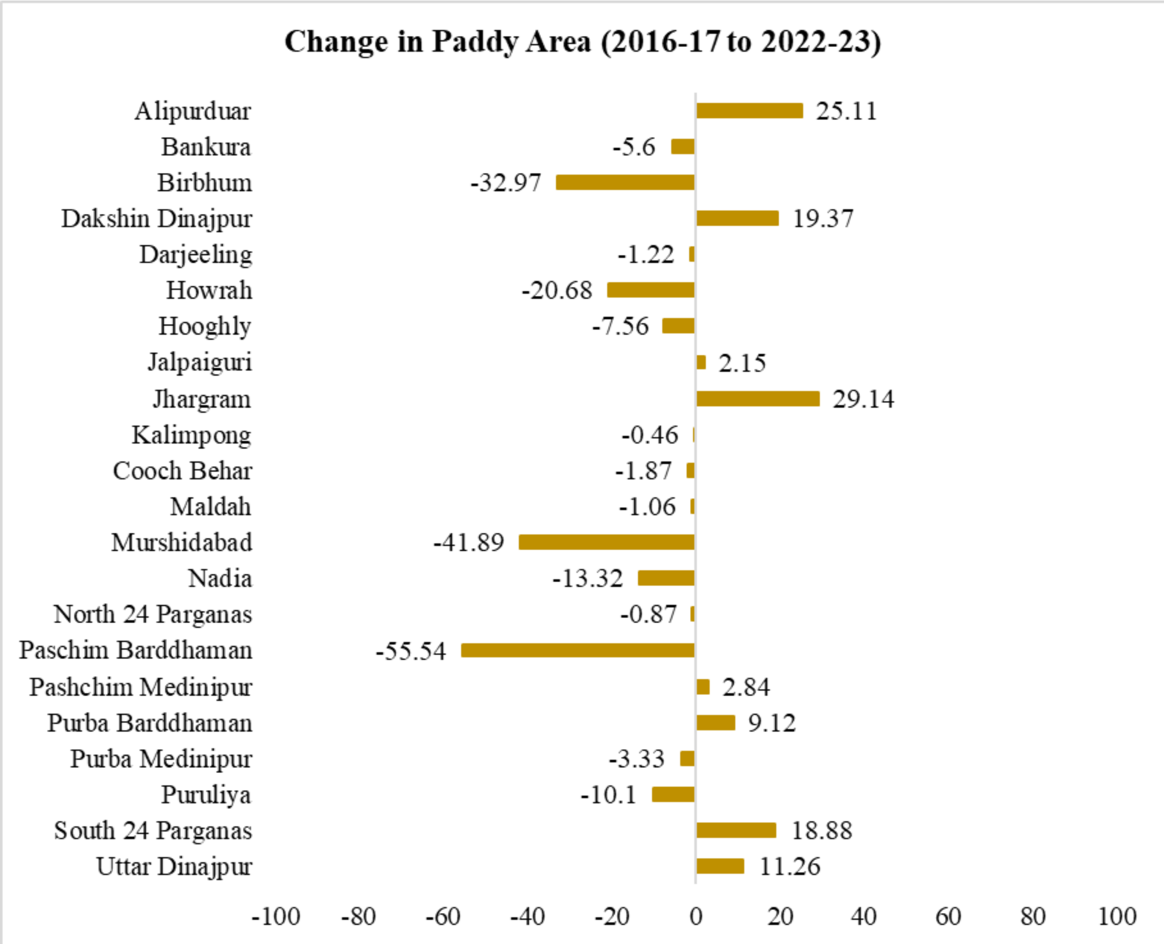
In contrast, Alipurduar, both Uttar and Dakshin Dinajpur in the northern part, and South 24-Parganas and Jhargram in the southern part of West Bengal, have recorded a moderate increase in paddy area (10% to 30%). Following that, Purba Barddhaman, Paschim Medinipur, and Jalpaiguri are showing a slight change in paddy area (less than 10%). So, in a nutshell, it can be concluded that, in terms of percentage change in paddy area, the northern part of West Bengal has performed better from 2016-17 to 2022-23.



Sources: DA&FW, MoA&FW and Author's Calculation

Figure 4.1: Mapping of District-wise Percentage Change in Paddy Area from 2016-17 to 2022-23

The following Figure 4.2 is a replica of the map above, with all data provided. All the negative values on the left-hand side indicate the percentage decrease, while the positive values on the right-hand side show the percentage increase of the paddy areas across the districts of West Bengal in the period of 2016-17 to 2022-23.



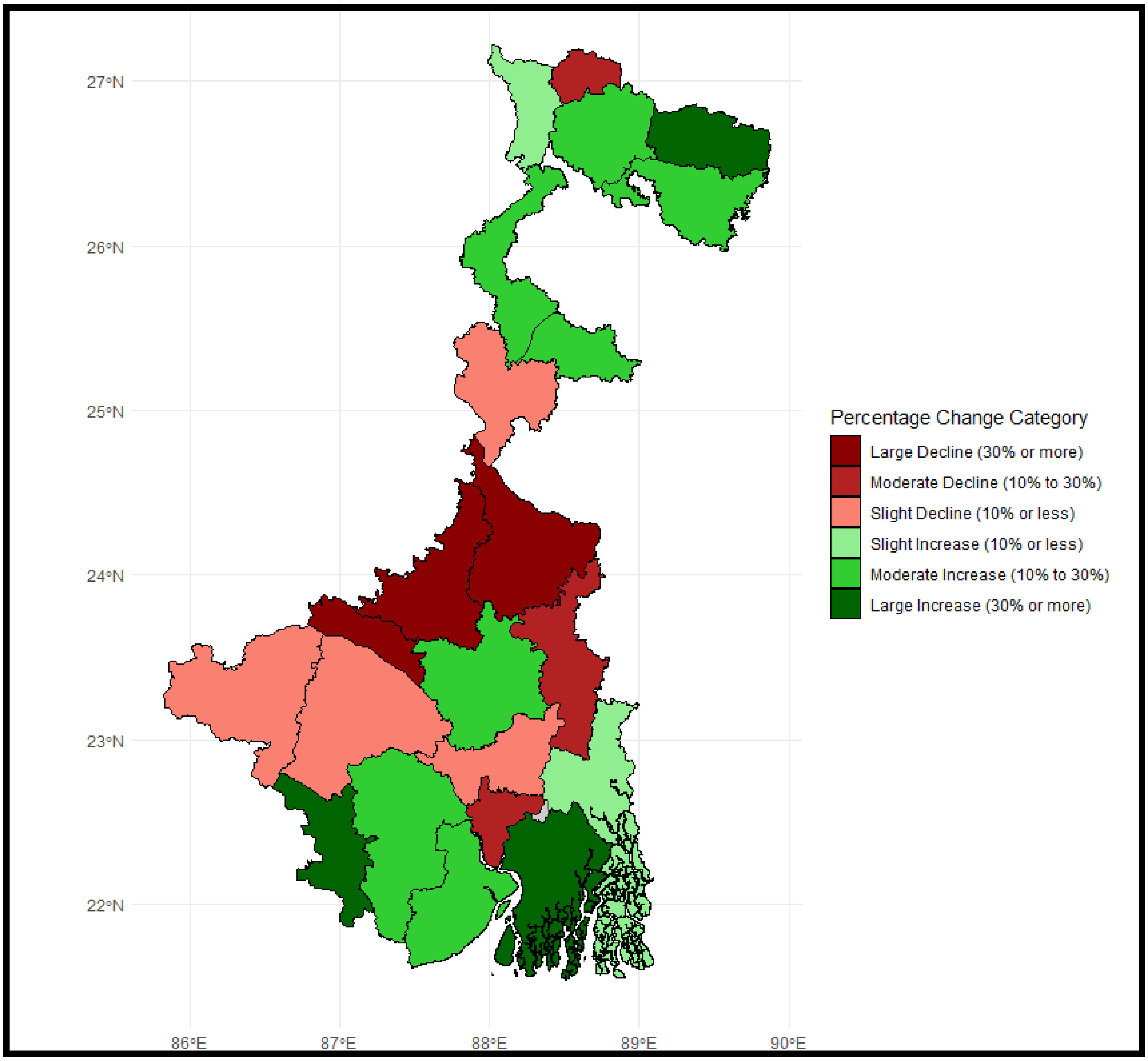
Sources: DA&FW, MoA&FW and Author's Calculation

Figure 4.2: District-wise Percentage Change in Paddy Area from 2016-17 to 2022-23

4.2. Mapping and Analyzing Rice Production in West Bengal

Here, following the same approach, a by-colour map below shows the district-wise percentage change in rice production from 2016-17 to 2022-23. The two main colours are used here: Red (Deepest to Lighter), where deepest shows the greatest decrease in rice production, and Green (Deepest to Lighter), where deepest shows the increase in rice production during the particular period in West Bengal.

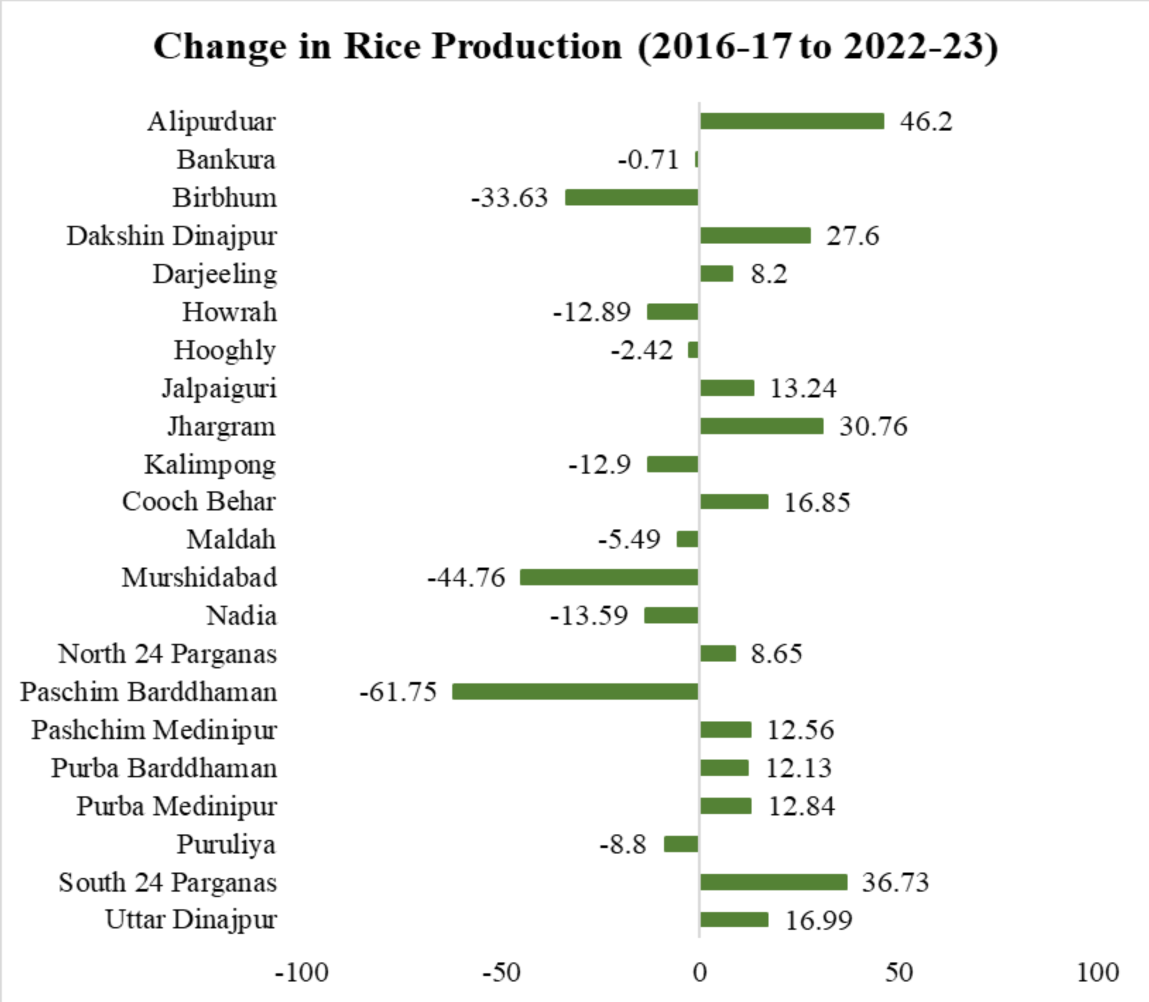
The Map displays certain districts, such as Alipurduar, South 24 Parganas, Jhargram, and Dakshin Dinajpur, that experienced substantial increases, where Alipurduar recorded the highest growth at over 46 percent. In contrast, districts like Paschim Barddhaman, Murshidabad, and Birbhum witnessed sharp declines, with Paschim Barddhaman facing the steepest fall of more than 60 percent. Several districts, including Nadia, Howrah, and Purulia, also registered moderate decreases, while others, such as Jalpaiguri, Cooch Behar, and Purba Medinipur, showed modest gains. Overall, the chart underscores the uneven trajectory of rice production across the state, reflecting localized factors such as climatic conditions, irrigation facilities, and agricultural practices that may have influenced these divergent outcomes.



Sources: DA&FW, MoA&FW and Author's Calculation

Figure 4.3: Mapping of District-wise Percentage Change in Rice Production from 2016-17 to 2022-23

The following Figure 4.4 presents the data for the map above, showing the percentage change in rice production during that period. Here, all the data are plotted as before, area change percentage (Figure 4.2). Here we can see and compare each district's percentage change in rice production in West Bengal from 2016-17 to 2022-23.



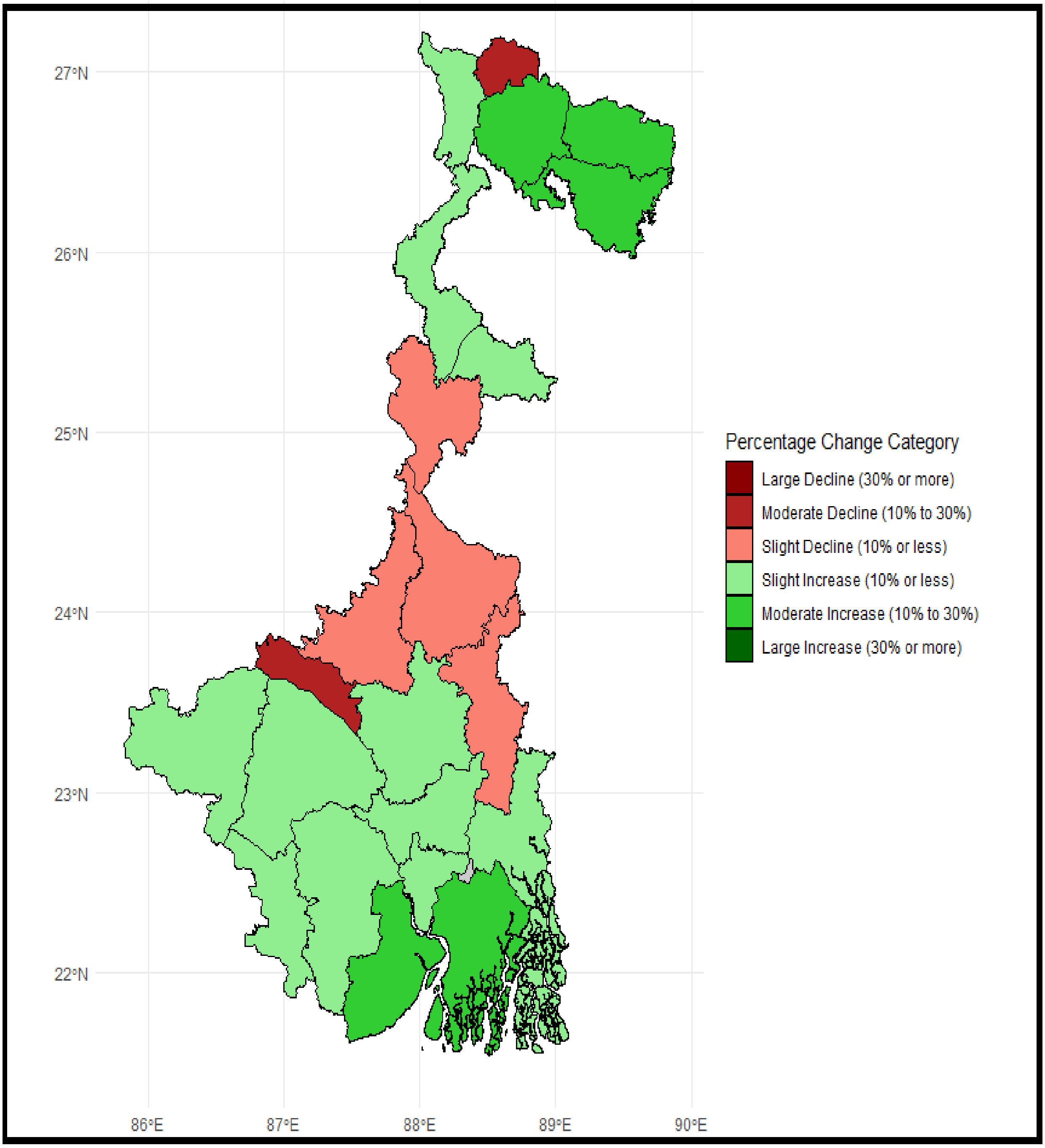
Sources: DA&FW, MoA&FW and Author's Calculation

Figure 4.4: District-wise Percentage Change in Rice Production from 2016-17 to 2022-23

As mentioned earlier, the highest increase in rice production (in percentage) has occurred in Alipurduar (46.2%), followed by South-24 Parganas (36.73%) and Jhargram (30.76%), all of which are over 30%, indicating the deepest green on the map. So, in that case, South Bengal is represented by several districts. But it is also notable that Paschim Barddhaman, Murshidabad, and Birbhum experienced the largest decline in rice production (over 30%), underscoring the need for district-centric planning. It is possibly happening due to crop diversification from rice to other crops, as in these three districts, paddy areas have also decreased by over 30 per cent, as mentioned in Figures 4.1 and 4.2. So, we can conclude from here, in an overall look, that North Bengal is a better performer than South Bengal in the percentage change in rice production at that particular period.

4.3. Mapping and Analyzing Yield of Paddy in West Bengal

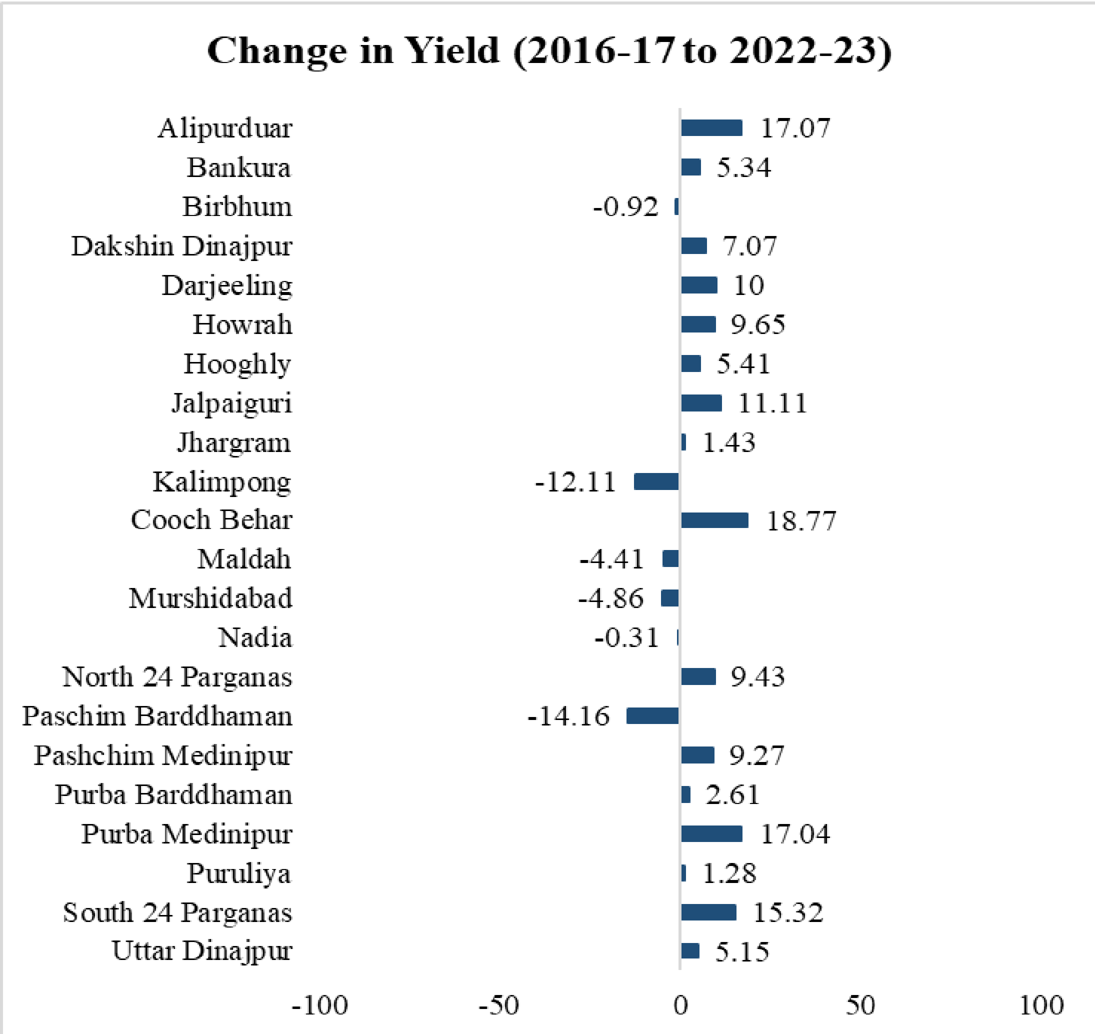
The combined analysis of Figures 4.5 and 4.6 shows that the district-wise percentage change in paddy yield in West Bengal from 2016–17 to 2022–23 reveals a highly uneven pattern across the state, with both spatial and numerical variations.



Sources: DA&FW, MoA&FW and Author's Calculation

Figure 4.5: Mapping of District-wise Percentage Change in Yield of Paddy from 2016-17 to 2022-23

The mapping highlights that several northern and central districts, such as Murshidabad, Paschim Barddhaman, and Kalimpong, experienced moderate to large declines, while southern and certain eastern districts, including South 24 Parganas, Purba Medinipur, and Cooch Behar, recorded significant increases. When the mapped categories are read alongside the district-level data, it becomes clear that the most notable gains in yield were achieved in Cooch Behar, Alipurduar, Purba Medinipur, and South 24 Parganas, each registering double-digit growth, with Cooch Behar leading with 18.77 percent. In contrast, Paschim Barddhaman (-14.16%) and Kalimpong (-12.11%) recorded moderate decreases (ranging from 10% to 30%), while Murshidabad and Maldah also showed slightly negative trends, within the 10% range. A number of districts, such as Nadia, Birbhum, and Purulia, remained relatively stagnant with negligible changes. Overall, Figure 4.5 and Figure 4.6 i.e., the map and the bar chart, respectively emphasize the regional disparities in paddy yield performance, pointing to localized factors such as irrigation infrastructure, soil fertility, climatic unpredictability and adoption of improved cultivation practices that have shaped these divergent outcomes. This spatial and statistical synthesis provides a clearer picture of where productivity gains have been concentrated and where interventions may be necessary to arrest decline and ensure balanced agricultural growth across the districts or Agro-Climatic zones of West Bengal.



Sources: DA&FW, MoA&FW and Author's Calculation

Figure 4.6: District-wise Percentage Change in Yield of Paddy from 2016-17 to 2022-23

Chapter-5: Exploring the Non-Cultivation of Rice Fallow Lands in West Bengal: Insights from Primary Data

5.1. Socio-Economic Status of the Respondents

Table 5.1 reveals the gender-wise distribution of respondents across two districts, i.e., Birbhum and South 24-Parganas, with each contributing 72 individuals to the total sample of 144 beneficiaries under the TRFA Programme. In Birbhum, male respondents constitute a significant majority, accounting for 65 individuals (45.14%), whereas female respondents are only 7 (4.86%). Conversely, South 24-Parganas shows a more balanced representation, with 31 female respondents (21.53%) and 41 male respondents (28.47%). Overall, among 144 respondents, 106 are male (73.61%), and 38 are female (26.39%), indicating a notable gender disparity in participation, particularly in Birbhum.

Table 5.1: Details of Gender Dynamics of the Selected Samples in West Bengal

Respondent's Gender	Female		Male		Grand Total	
Districts	**Numbers of Respondent**	**%**	**Numbers of Respondent**	**%**	**Numbers of Respondent**	**%**
Birbhum	7	4.86	65	45.14	72	50
South 24-Parganas	31	21.53	41	28.47	72	50
Total	**38**	**26.39**	**106**	**73.61**	**144**	**100**

Source: Primary survey 2024-25 and authors' Calculation

The average age and farming experience of male and female respondents across two districts are shown in Table 5.2. In Birbhum, female respondents have an average age of 51 years and 25 years of farming experience, while male respondents have an average age of 52 years and 30 years of farming experience. The overall district average is 52 years of experience. In South 24-Parganas, female respondents had an average age of 49 years and 23 years of farming experience, while male respondents were older, with an average age of 58 years and 38 years of experience. The district's overall average age is 54, and the average farming experience is 32 years. When combined, the total sample shows that female respondents average 50 years of age and 24 years of experience, whereas male respondents average 55 years of age and 34 years of experience. The grand total averages across both districts are 53 years of age and 31 years of farming experience. This scenario suggests that male respondents tend to be older and have more years of farming experience than their female counterparts, particularly in South 24 Parganas.

Table 5.2: Average Age and Farming Experience of the Selected Respondents

Respondent's Gender	Female		Male		Total	
Districts	Age (Years)	Farming Experience (Years)	Age (Years)	Farming Experience (Years)	Age (Years)	Average Farming Experience (Years)
Birbhum	51	25	52	30	52	30
South 24-Parganas	49	23	58	38	54	32
Total	**50**	**24**	**55**	**34**	**53**	**31**

Source: Primary survey 2024-25 and authors' Calculation

Table 5.3 presents a comparative view of average years of education across caste groups in two sample districts of West Bengal, namely Birbhum and South 24 Parganas, for that report. General category respondents have the highest educational attainment, especially in Birbhum (9.83 years), while Other Backwards Classes (OBC) and Scheduled Castes (SC) show lower averages, with OBCs in South 24 Parganas averaging just 5.43 years and SCs in Birbhum at 6.13 years. Scheduled Tribe (ST) respondents in Birbhum show a relatively better average (7.00 years), although their sample size is small. The overall average education level is higher in Birbhum (8.90 years) than in South 24-Parganas (7.32 years), suggesting district-level disparities in educational access.

Table 5.3: Status of Educational Profile across Social Categories of the Respondents

Particulars	Castes	Districts		Total
		Birbhum	South 24-Parganas	
Average years of Education	**General**	9.83	7.78	8.76
	OBC (Other Backwards Classes)	NA	5.43	5.43
	SC (Scheduled Castes)	6.13	NA	6.13
	ST (Scheduled Tribes)	7	NA	7
	Grand Total	**8.9**	**7.32**	**8.11**
Count	General	53	58	111
	OBC (Other Backwards Classes)	0	14	14
	SC (Scheduled Castes)	15	0	15
	ST (Scheduled Tribes)	4	0	4
	Grand Total	**72**	**72**	**144**

Source: Primary survey 2024-25 and authors' Calculation

From the agricultural economics outlook, these differences have direct implications for constructing policy design. Higher levels of education often correlate with greater receptiveness to training, adoption of sustainable practices, and engagement with schemes such as the System of Rice Intensification (SRI) or precision farming. The lower educational attainment among OBCs and SC groups calls for inclusive, simplified communication strategies and localized capacity-building efforts. The efficiency of agricultural interventions can be significantly boosted by tailoring rural extension services to these socio-educational profiles.

Table 5.4 below compares household composition across two districts (Birbhum and South 24 Parganas) by family type and average household size. Families are categorized as either joint or nuclear. In Birbhum, there are 33 joint families with an average of 6 members and 39 nuclear families with an average of 3 members, totalling 72 families with an overall average household size of 4.5. South 24-Parganas shows a similar pattern, with 31 joint families averaging 6 members and 41 nuclear families averaging 4 members, mirroring the total: 72 families with an average household size of 4.5. The combined data from both districts yields 64 joint families and 80 nuclear families, totalling 144 families and a consistent average household size of 4.5. This suggests that while joint families tend to be larger, the overall household size remains balanced across regions due to the mix of family types.

Table 5.4: Household Insights: Family Types and Average Sizes among Respondents

	Joint		Nuclear		Total Count of Family Type	Total Average of Household size
Districts	**Count of Family Type**	**Average Household Size**	**Count of Family Type**	**Average Household Size**		
Birbhum	33	6	39	3	72	4.5
South 24-Parganas	31	6	41	4	72	4.5
Total	**64**	**6**	**80**	**3.5**	**144**	**4.5**

Source: Primary survey 2024-25 and authors' Calculation

Table 5.5 below depicts that Birbhum district holds 148.12 acres of owned land, indicating a substantial base for direct agricultural operations. Additionally, 23.23 acres have been leased in, expanding the cultivable area through temporary arrangements. There is no leased land, suggesting full retention of available plots for internal use. However, 22.39 acres remain fallow, which may be due to irrigation problems, soil recovery issues, or resource constraints. Whereas South 24-Parganas has 38.85 acres of owned land, supplemented by 36.85 acres of leased-in land across sample farmers, indicating reliance on external holdings to support agricultural activities.

A small portion, 0.72 acres, is leased for possible cooperative or shared use. The district also has 18.49 acres of fallow land, which can be targeted for future cultivation or ecological restoration.

Table 5.5: Pre-TRFA Land Holdings: A Snapshot of Respondent Operations

Districts	owned land (in acres)	Leased-in land (in acres)	Leased-out land (in acres)	Fallow land (in acres)
Birbhum	148.12	23.23	0	22.39
South 24-Parganas	38.85	36.85	0.72	18.49
Total	**186.97**	**60.08**	**0.72**	**40.88**

Source: Primary survey 2024-25 and authors' Calculation

Across both districts, the total owned land amounts to 186.97 acres, with 60.08 acres leased in and only 0.72 acres leased out. The combined fallow land totals 40.88 acres, representing a significant opportunity for crop diversification, soil improvement, or climate-resilient farming interventions.

Table 5.6: Land Ownership and Fallow Patterns: Social Group Analysis before TRFA

Particulars	Districts	Birbhum	South 24-Parganas	Total
Owned land	General	136.72	34.46	171.18
	OBC (Other Backwards Classes)	NA	4.39	4.39
	SC (Scheduled Castes)	6.58	NA	6.58
	ST (Scheduled Tribes)	4.82	NA	4.82
	Total	**148.12**	**38.85**	**186.97**
Fallow land	General	17.63	15.07	32.70
	OBC (Other Backward Classes)	NA	3.43	3.43
	SC (Scheduled Castes)	3.99	NA	3.99
	ST (Scheduled Tribes)	0.77	NA	0.77
	Total	**22.39**	**18.50**	**40.89**

Source: Primary survey 2024-25 and authors' Calculation

The calculation in Table 5.6 provides a comparative overview of land ownership and fallow land distribution across two districts (Birbhum and South 24-Parganas), classified by social group. It is evident from the above table that a significantly higher total of owned agricultural land (148.12

hectares) has been recorded in Birbhum compared to South 24-Parganas (38.85 hectares), resulting in a combined total of owned land holdings of 186.97 hectares. The majority of this land is held by the General category, with 136.72 hectares in Birbhum and 34.46 hectares in South 24-Parganas. Contributions from Other Backward Classes (OBC), Schedule Castes (SC) and Schedule Tribes (ST) groups are either limited or not available in one of the districts as we can see that OBC ownership of agricultural land recorded only in South 24-Parganas district (4.39 hectares), on the other hand SC and ST ownership of agricultural land only in Birbhum district (6.58 hectares and 4.82 hectares, respectively). Now, focusing on the scenario of fallow land, Birbhum accounts for 22.39 hectares, whereas South 24-Parganas contributes 18.50 hectares, totalling 40.89 hectares. The General category again holds the majority, with 17.63 hectares in Birbhum and 15.07 hectares in South 24-Parganas. OBC fallow land is recorded only in South 24-Parganas (3.43 hectares), while SC and ST fallow land are present only in Birbhum, with 3.99 and 0.77 hectares respectively. The absence of data for certain groups in specific districts suggests either a lack of ownership or the unavailability of records. This distribution highlights regional and social disparities in land access and utilization, which should be communicated to the agricultural planning authorities (for this study, the state-specific controlling authority of the TRFA programme), such that inclusive land development strategies can be properly designed and implemented in the near future, as is needed for the agricultural sector.

Before looking at the data in Table 5.7, it is important to describe the various irrigation sources and methods that are mentioned in the questionnaire, as mentioned below:

Sources of Irrigation:

Canal Irrigation: This source involves diverting water from rivers or reservoirs through a network of canals to agricultural fields. It is typically managed by government or community systems and is suitable for large-scale irrigation in regions with reliable surface water availability. Canal irrigation supports crops like paddy, wheat, and sugarcane, especially in alluvial plains.

Tank Irrigation: Tank irrigation utilizes water stored in small to medium-sized reservoirs or tanks, often constructed by embanking natural depressions. Common in semi-arid and plateau regions, tanks are filled by rainwater or diverted streams and serve as a decentralized source for irrigation. This source supports seasonal cropping and helps to recharge groundwater.

Well and Tube Well Irrigation: This source draws groundwater using open wells or deep tube wells fitted with pumps. It provides assured irrigation, especially in areas with low rainfall or unreliable surface water. Tube wells are more efficient and suitable for intensive cropping, but excessive use may lead to groundwater depletion and require regulation.

River Lift Irrigation: River lift systems involve pumping water directly from rivers and conveying it to nearby fields. As a source of irrigation, this is effective in regions where canal systems are absent, but rivers flow close to agricultural zones. It enables irrigation during dry spells and supports crops requiring moderate water input.

Rainwater Harvesting: Rainwater harvesting captures and stores rainwater for agricultural use through structures such as farm ponds, check dams, and percolation pits. It enhances water availability during dry periods, promotes groundwater recharge and supports supplementary irrigation for drought-resilient farming.

Traditional Water Harvesting Techniques: This includes indigenous sources, which are region-specific systems developed over centuries. They rely on local topography and community participation to collect and distribute water. These techniques are eco-friendly, cost-effective and crucial for sustainable agriculture in rainfed and tribal areas.

Methods of Irrigation:

Drip irrigation: This method of irrigation delivers water directly to the root zone of crops through a network of pipes and emitters, minimizing evaporation and runoff. It is highly efficient and suitable for horticultural crops, orchards and water-scarce regions.

Sprinkler irrigation: It mimics natural rainfall by spraying water over crops using rotating nozzles or fixed systems. It ensures uniform coverage and is ideal for a wide range of crops, especially in rolling terrains.

Surface irrigation: This method involves distributing water across the field by gravity. Common techniques include flood, furrow, and basin irrigation. Though widely practised due to low cost, it often results in water wastage and uneven distribution.

Alternate Wetting and Drying (AWD): It is a controlled irrigation method used primarily in paddy cultivation. It involves periodic drying of the field between irrigations, reducing water use and methane emissions while maintaining yield.

Manual irrigation: This method of irrigation involves applying water with buckets, watering cans, or simple tools. It is labour-intensive and typically used in small-scale farming or kitchen gardens where mechanized systems are not feasible.

Table 5.7: Watering Wisdom: Irrigation Sources and Methods among Respondents

(All in Numbers of Household)

Particulars	Districts	Birbhum	South 24-Parganas	Total
Irrigation sources	Canal Irrigation	1	49	50
	Tank Irrigation	NA	NA	NA
	Well and Tube Well Irrigation	71	2	73
	River Lift Irrigation	NA	16	16
	Rainwater Harvesting	NA	5	5
	Traditional Water Harvesting Techniques	NA	NA	NA
	Grand Total	**72**	**72**	**144**
Irrigation method	Drip Irrigation	3	NA	3
	Sprinkler Irrigation	NA	NA	NA
	Surface Irrigation (Flood, Furrow, Basin)	69	72	141
	Alternate Wetting and Drying (AWD)	NA	NA	NA
	Manual Irrigation	NA	NA	NA
	Grand Total	**72**	**72**	**144**

Source: Primary survey 2024-25 and authors' Calculation

Now, turning to Table 5.7, which presents district-wise household-level use of irrigation sources and methods across Birbhum and South 24-Parganas among a total of 144 sample households (HHs). In terms of irrigation sources, Birbhum relies heavily on well and tube-well irrigation (71 HHs), while South 24-Parganas shows greater diversification, with significant uptake of canal irrigation (49 HHs), rainwater harvesting (5 HHs), and river lift irrigation (16 HHs). It is quite understandable as South 24-Parganas is a mix of both Gangetic Alluvial and Coastal Saline Agro-climatic Zones. This suggests a contrast between groundwater dependency and utilization of surface and harvested water, likely influenced by hydrogeological and infrastructural factors.

Among irrigation methods, surface irrigation (including flood, furrow, and basin techniques) is overwhelmingly dominant, accounting for 141 of 144 households, indicating its continued dominance in traditional agricultural practices. Drip irrigation is minimally adopted in Birbhum (3 HHs), and no households reported using manual or sprinkler irrigation, pointing to limited penetration of modern or semi-mechanised systems. The absence of such methods may reflect constraints in capital investment and awareness. Alternate Wetting and Drying (AWD) is also entirely absent for various reasons, such as ecological incompatibility, inadequate institutional support, and low levels of awareness. Targeted extension efforts, pilot demonstrations and localized adaptation strategies could help assess its feasibility and promote acceptance where it will be appropriate.

Therefore, from an agro-economic viewpoint, the data highlight the need for district-specific irrigation planning. Birbhum requires interventions focused on groundwater sustainability, the promotion of water-saving technologies, and institutional support for the adoption of micro-irrigation. South 24 Parganas can benefit from scaling up decentralized water-harvesting and lift-irrigation systems, especially in saline-prone or low-lying areas. Both districts would benefit from targeted capacity-building programs, financial incentives, and improved extension services to enhance irrigation efficiency and climate resilience.

5.2. Exploring the Reasons behind the Non-Cultivation of Rice Fallow Land in the Pre-TRFA Period

The utilization of rice fallow land holds significant potential for enhancing agricultural productivity, ensuring food security and promoting sustainable land use in India. However, despite this potential, a substantial portion of rice-fallow land remained uncultivated during the Pre-TRFA period. The below-mentioned Table 5.8 presents a detailed breakdown, in descending order, of the various reasons that discouraged farmers from cultivating the rice fallow lands before the implementation of the Targeted Rice Fallow Area programme by the Government of India.

Table 5.8: Reasons behind the Non-Cultivation of Rice Fallow Land in Pre-TRFA Period

SL No.	Reasons	Count of Each Reason
1	**Climate Vulnerability:** Risks associated with climate change/variability, such as droughts or floods, made crop cultivation risky	88
2	**Water Scarcity:** Limited water availability or unreliable irrigation infrastructure hinder rice cultivation	73
3	**Input Costs:** High input costs, including seeds, fertilizers, and pesticides, out-weighted potential returns	48
4	**Labour Intensity:** Crop cultivation required significant manual labour, which was costly or unavailable	31
5	**Soil Health Concerns:** Prioritized fallow periods to restore soil fertility and structure	30
6	**Government Policies:** Government regulations or subsidies favoured other crops, or land uses over rice cultivation	24
7	**Land Health issues:** Salinity, alkalinity, etc.	20
8	**Any other issues:** (Disease and pest infestation, drainage problems, Poor seed quality, etc.)	8
9	**Market Access Issues:** Limited access to markets or transportation challenges hindered rice sales	4
10	**Low Market Demand:** Insufficient demand or low prices for the crop made cultivation economically unviable	2
Grand Total		**328**

Source: Primary survey 2024-25 and authors' Calculation

The reasons were identified through a primary survey conducted in 2024-25 that captured reflective insights from farmers' perceptions across two sample districts, and in which the option of multiple selection was allowed. The responses reflect a complex interplay of climatic, economic, agronomic, and institutional factors that influenced farmers' decisions, as already mentioned in the literature review.

5.2.1. Climate Vulnerability (88 responses)

Climate variability emerged as the most significant warning against the non-cultivation of rice fallows. Farmers revealed frequent droughts, erratic rainfall patterns, and flooding as major risks that compromise crop survival and yield. These climate-induced uncertainties discouraged investment in farming pulses or oilseeds in the rabi season in rice fallows, especially in South 24-Parganas (62 out of 88 responses, i.e., 70% of all responses about climate variability), as the proximity to perennial rivers (where there is continuous flow in parts of their stream bed throughout the year during normal rainfall) is very short for this sample district. The fear of crop failure due to unpredictable weather patterns led many to leave their land fallow as a risk-averse strategy.

5.2.2. Water Scarcity (73 responses)

Rice fallow lands often lack residual soil moisture, making them unsuitable for water-intensive crops without supplemental irrigation. The second most alarming reason was inadequate water availability. 21.13 acres out of 40.88 acres (52%) of rice-fallow land lacked access to dependable irrigation sources during that period. In some cases, irrigation infrastructure existed but was poorly maintained. Limited access to irrigation, whether due to poor canal infrastructure, depleted groundwater and unreliable rainfall, was a major deterrent. Without a reliable water supply during the rabi season, farmers were reluctant to cultivate pulses or oilseeds, even though these are less water-intensive crops.

5.2.3. High Input Costs (48 responses)

It is important to note that economic constraints played a crucial role in discouraging farmers from leaving fallow after harvesting rice. The rising cost of agricultural inputs, such as certified and quality seeds, chemical fertilizers and pesticides, and the cost of land preparation made winter farming financially unviable for many smallholders, especially in marginal areas. When the expected returns did not justify the upfront investment, farmers opted to leave the land uncultivated. Without assured procurement or price support, farmers were reluctant to risk capital on uncertain yields.

5.2.4. Labour Intensity (31 responses)

Pulse and Mustard cultivation demands moderate to high manual labour, particularly during land preparation, transplanting, and harvesting. In areas facing labour shortages due to migration or ageing rural populations or where labour costs were prohibitively high, farmers found it difficult to manage cultivation operations. The lack of mechanization further exacerbated this challenge, making rice farming labour-intensive and costly.

5.2.5. Soil Health Concerns (30 responses)

Some farmers intentionally left land fallow to rejuvenate soil fertility and structure. Continuous cropping without adequate nutrient replenishment has led to soil fatigue in many regions. Fallowing was seen as a restorative practice to improve organic matter content, microbial activity, and overall soil health, thereby ensuring better productivity in subsequent seasons.

5.2.6. Government Policies (24 responses)

Policy-level factors also influenced cultivation decisions. In our sample villages, government subsidies or support programs can favour alternative crops (e.g., pulses, oilseeds) or land uses (e.g., horticulture, aquaculture). Therefore, the lack of targeted support for rice fallow utilization results in limited diversification.

5.2.7. Land Health Issues (20 responses)

Soil degradation due to salinity, alkalinity and poor drainage reduced the suitability of land for post-rice cropping. These land health issues often stemmed from poor drainage, overuse of chemical inputs, or proximity to saline water bodies. Without adequate reclamation measures, farmers were forced to abandon cultivation on affected plots. These physical constraints require reclamation measures and site-specific agronomic planning.

5.2.8. Any Other Issues (8 responses)

A small subset of farmers reported miscellaneous challenges, including disease and pest infestations that damaged previous crops, poor seed quality resulting in low germination rates, and drainage problems that caused waterlogging or runoff. These issues, though less frequent, contributed to the decision to leave the land fallow.

5.2.9. Market Access Issues (4 responses)

Limited access to markets and poor transportation infrastructure discouraged cultivation. Farmers in remote areas struggled to sell their produce due to a lack of nearby mandis or local wholesale markets, high transport costs or the absence of procurement centres. Additionally, it hindered market access, reducing incentives for surplus production. Without aggregation or cooperative marketing, farmers faced low price realization. In our sample villages, there are too few minor responses, i.e., for Birbhum, it is one and for South 24-Parganas, it is three, which reveal that market access is not a critical issue regarding the total sample households.

5.2.10. Low Market Demand (2 responses)

In rare instances, farmers cited low consumer demand or depressed market prices for the second-season crop as a reason for non-cultivation or making cultivation economically unattractive (In Birbhum, one respondent cited this, and in South 24-Parganas, one response came in favour of this reason, probably due to their reluctance or lack of knowledge.

So, the decision to leave rice-fallow land uncultivated in the pre-TRFA period was shaped by a complex interplay of climatic, economic, and institutional factors. Based on primary survey data (2024-25), addressing these constraints through targeted interventions such as climate-resilient infrastructure, input subsidies, soil health programmes and improved market access has become the need of the hour to unlock the potential of fallow lands and enhance agricultural productivity. At that time, understanding the above-mentioned reasons for the non-cultivation of rice fallows was vital for policymakers, researchers, and extension agencies seeking to design effective interventions, including proper resource utilisation, climate resilience, and integrated planning. Therefore, later, a well-designed Targeted Rice Fallow Areas programme was launched and implemented.

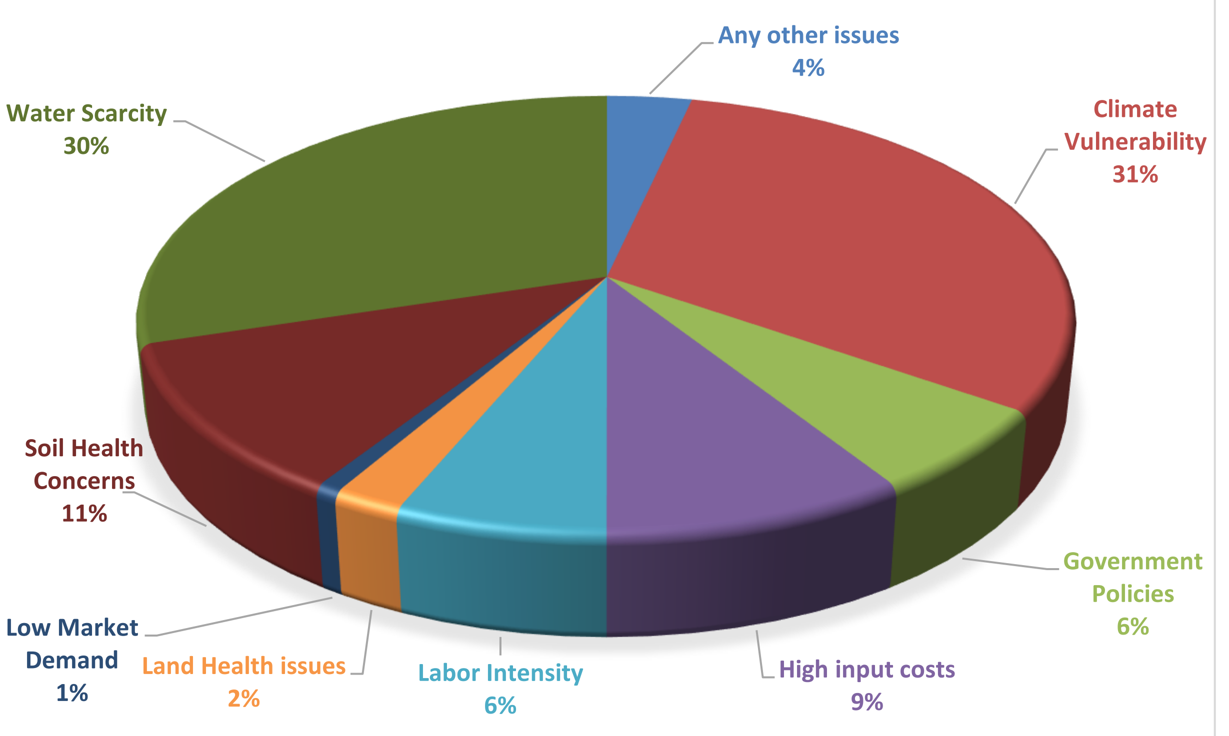
5.2.11. Top reason

We have already discussed multiple opinions or reasons for leaving the rice fallows uncultivated before launching the TRFA programme in West Bengal. But Figure 5.1 shows the main reason for the non-cultivation of those rice fallow lands. This pie chart illustrates the multifaceted challenges associated with the rejuvenation of rice fallow lands, offering a quantitative breakdown of agro-economic constraints that hinder sustainable utilization of these underused areas. The data reflect farmers' perceptions and field-level realities, which were very crucial in designing targeted interventions at that time, i.e., before 2016-17.

Here, the most significant concern is climate vulnerability (45 farmers, 31%), underscoring the susceptibility of rice fallow regions to erratic saline water intrusion, erratic rainfall, and weather extremes. These factors directly affected the feasibility of introducing second crops or diversified farming systems post-rice harvest (especially in South 24-Parganas, 41 out of 45 responses, i.e., 91%). Water scarcity (43 farmers, 30%) appeared as an equally pressing issue then, particularly in regions lacking irrigation infrastructure or facing declining groundwater levels. Without assured water availability, the potential for crop intensification remains limited (especially in Birbhum, 33 out of 43 responses, i.e., 77%). So, the combination of these two constraints significantly hampered the ability to leave the rice fallow lands uncultivated in the Pre-TRFA period. Soil health concerns (16 farmers, 11%) point to degradation, nutrient depletion, and low organic matter content, resulting in reduced productivity and increased reliance on inputs. This reason was more alarming in Birbhum

(11 out of 16 responses, i.e., 69%) than South 24-Parganas (5 out of 16 responses, i.e., the remaining 31%). High input costs (13 farmers, 9%) reflect the economic burden of seeds, fertilisers, labour and mechanization, often discouraging small agricultural landholders from investing in rice fallow land cultivation in the rabi season. Both the Government policies and labour intensity (9 farmers, 6%) highlight systemic and operational barriers during the Pre-TRFA period, ranging from inadequate policy incentives to the materialistic demands of crop cultivation (especially pulses and mustard) in rice-fallow lands.

Minor so far relevant reasons include any other issues (5 farmers, 4%), which involved Disease and pest infestation, drainage problems, and poor seed quality, as obtained from farmers' information. Land health issues (3 farmers, 2%) suggest localized degradation, alkalinity and salinity concerns, while only 1 farmer remarked on low market demand (1%) as the top reason for non-cultivation of rice fallows, which indicates limited profitability, poor market linkages and lack of awareness for alternative crops grown on rice fallow lands. It is important to note that no one has chosen Market Access Issues (limited access to markets or transportation challenges hindering rice sales) as a top reason, whereas in multiple selections, 4 responses have selected this constraint. Again, it happened due to a lack of marketing awareness.



Source: Primary survey 2024-25 and authors' Calculation

Figure 5.1: Major Reasons for Not Cultivating the Rice Fallow Land

Therefore, in a nutshell, Figure 5.1 emphasizes the need for integrated agro-economic strategies, such as climate-resilient cropping systems, low-cost water solutions, soil restoration practices, and policy reforms at that time, to unlock the latent potential of rice fallow lands. Addressing these constraints entirely can contribute to enhanced food security, rural livelihoods and ecological sustainability.

From a statistical viewpoint, the chi-square test of the null hypothesis (H_0) reveals that there is no significant difference between the observed and expected frequencies. For this study, the null hypothesis states that "There is no significant difference among the observed reasons for not cultivating the rice fallow land." The Chi-square statistic (1.2×10^3) indicates the extent of deviation between the observed and expected frequencies, with higher values indicating greater disparity.

The corresponding p-value of 0.000 indicates the probability of obtaining the observed data or a more extreme outcome, assuming the null hypothesis is true. A low p-value suggests that the observed differences are highly unlikely to have occurred by chance. Since the p-value is below the conventional threshold of significance (e.g., 0.10 or 10% level of significance), the null hypothesis is rejected, and the alternative hypothesis (There is a significant difference among the observed reasons for not cultivating the rice fallow land) is accepted. This proves that there is a statistically significant difference among the reasons mentioned by sample households for not cultivating rice fallow land in the pre-TRFA period.

Therefore, Table 5.9 below shows that "Climate Vulnerability" is the most frequently mentioned reason, followed by "Water Scarcity". As mentioned earlier, climate vulnerability highlights the exposure of agricultural systems to erratic weather patterns, such as delayed monsoons, unseasonal rainfall, and the increasing frequency of extreme events, which are significantly disrupting the predictability and viability of cultivation in rice fallow lands. In addition, limited water availability and unreliable irrigation infrastructure were consistently identified as major constraints, indicating that water-related challenges played a decisive role in shaping farmers' decisions regarding rice fallow land cultivation at that time. Together, these challenges reflect a wider pattern of climate-induced production risk and resource insecurity, which were vital to the agro-economic decision-making process by the Government in the Pre-TRFA period.

On the other hand, the sample farmers have not suffered significantly in terms of labour intensity, land health issues, or problems related to lower market demand. The labour intensity issue is not a crucial factor, as cultivation of pulses and oilseed (mustard) does not demand too many labourers. Low market demand is also not a factor that discourages farmers because the market prices of pulses and mustard are remunerative. Apart from that, farmers also use these for self-consumption.

Table 5.9: Chi-square Test

(Values are the top reasons/frequencies given by respondents)

Reasons	Climate Vulnerability	Water Scarcity	Soil Health Concerns	High input costs	Government Policies	Labour Intensity	Any other issues	Land Health issues	Low Market Demand	Total
1	45	0	0	0	0	0	0	0	0	45
2	0	43	0	0	0	0	0	0	0	43
3	0	0	16	0	0	0	0	0	0	16
4	0	0	0	13	0	0	0	0	0	13
5	0	0	0	0	9	0	0	0	0	9
6	0	0	0	0	0	9	0	0	0	9
7	0	0	0	0	0	0	5	0	0	5
8	0	0	0	0	0	0	0	3	0	3
9	0	0	0	0	0	0	0	0	1	1
Total	**45**	**43**	**16**	**13**	**9**	**9**	**5**	**3**	**1**	**144**

Source: Primary survey 2024-25 and authors' Calculation

[Pearson chi^2(64)] = 1.2e+03 (1.2×10^3) P-Value= 0.000

1. Climate Vulnerability
2. Water Scarcity
3. Soil Health Concerns
4. High input costs
5. Government Policies
6. Labour Intensity
7. Any other issues
8. Land Health issues
9. Low Market Demand

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5.3. Perceptions of TRFA Beneficiaries on Rice Fallow Land Cultivation in India

The survey also tried to capture the perception of TRFA beneficiaries (including TRFA- Pulses and Oilseeds) in the reference year 2023-24, regarding rice fallow land cultivation

Table 5.10: Percent Position and Garrett Value for each Factor

Rank	Percent position using the formula $100(R_{ij}-0.5)/N_j$	Garret value
1	0.35	52
2	1.04	52
3	1.74	38
4	2.43	35
5	3.13	28
6	3.82	26
7	4.51	24
8	5.21	22
9	5.90	15
10	6.60	6

Source: Primary survey 2024-25 and authors' Calculation

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1. Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
2. Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
3.Fertilization: Proper fertilization ensures plants receive essential nutrients for growth.
4. Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
5. Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
6. Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
7. Pest Management: Effective pest control is necessary to protect crops from damage.
8. Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
9. Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
10. Water Availability: Adequate water supply is crucial for successful

Table 5.10 shows the rank and its corresponding percentage position. In the methodology (Chapter II), it is already mentioned that Tables 5.10 and 5.11 are calculated by using, firstly, the Percent position using the formula $100*(R_{ij}-0.5)/N_j$, and the associated Garret values. Each row represents a rank from 1 to 10. The percentage position increases steadily as the rank rises, beginning at 0.35 for rank 1 and reaching 6.60 for rank 10. This progression reflects how the formula distributes ranks across a scale of 100, adjusting slightly by subtracting 0.5 before dividing by the total number of items (N_j). The Garret values, which are statistical weights often used in ranking analysis, decrease as the rank increases.

For each rank, the Garrett values are multiplied by the given value to get a total. This total is later divided by the number of respondents, shown in Table 5.11. Finally, we rank the factors based on their resulting scores. So, basically, Table 5.11 is the final rank or score accomplished by Table 5.10, considering the number of respondents.

The results of the Garrett ranking analysis explored several significant understandings, i.e., The highest garret scores (in Table 5.11) are of 11.19, assigned as ranks 1 and 2, i.e., *Disease Prevention: Measures to prevent diseases are vital for maintaining crop health,* and *Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields*, So, a higher score reveals that the particular perception is in a critical level. Therefore, disease prevention and soil fertility are the two major perceptions that need to be focused on. On the other hand, the lowest value of 0.04 corresponds to rank 10 (Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success), implying that most of the sample farmers ranked community support last in the last two rankings. Only 6 farmers ranked it as their first choice. This pattern shows that higher ranks are given greater weight as the number of opinions in the analysis increases, while lower ranks carry less weight. Overall, Tables 5.10 and 5.11 demonstrate the relationship between rank, the calculated per cent position, and the corresponding Garret value used for interpreting ranking visions.

Table 5.11: Garrett Score and its Ranking

Perceptions	Total	Score	Rank
Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success	6	0.04	10
Disease Prevention: Measures to prevent diseases are vital for maintaining crop health	1612	11.19	1
Fertilization: Proper fertilization ensures plants receive essential nutrients for growth	684	4.75	3
Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields	240	1.67	7
Land Suitability: Proper assessment of land suitability ensures optimal crop growth	336	2.33	5
Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits	198	1.38	8
Pest Management: Effective pest control is necessary to protect crops from damage	560	3.89	4
Seed Quality: High-quality seeds lead to better germination rates and stronger plants	286	1.99	6
Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields	1612	11.19	2
Water Availability: Adequate water supply is crucial for successful cultivation	75	0.52	9

Source: Primary survey 2024-25 and authors' Calculation

5.4. Evaluation of the TRFA Scheme and its Impact on Fallow Land Cultivation in West Bengal

The below-mentioned Table 5.12 elicits the season-wise crop count in the Pre-TRFA period, where it is seen that the average number of crops grown in both the sample districts, i.e., Birbhum and South 24-Parganas, is the same (1) in all three cropping seasons (kharif, rabi, and summer) along with West Bengal. The kharif, rabi, and summer crop counts, by the number of sample farmers, are 72, 43, and 15, respectively, in Birbhum. In the same manner, these figures are 66, 67, and 28 in South 24-Parganas. Therefore, these two sample districts total 138 in kharif, 110 in rabi, and 43 in the summer season.

Table 5.12: Season-wise Crop Counts: Pre-TRFA Insights from Respondents

Districts	Average number of crops grown			Season-wise count of crops		
	Kharif crops	Rabi crops	Summer crops	Kharif crops	Rabi crops	Summer crops
Birbhum	1	1	1	72	43	15
South 24-Parganas	1	1	1	66	67	28
Grand Total	**1**	**1**	**1**	**138**	**110**	**43**

Source: Primary survey 2024-25 and authors' Calculation

As mentioned earlier, the TRFA intervention in West Bengal (in our two sample districts) mostly occurs in the rabi season. Table 5.13 is the depiction of the responses from the sample farmers about Post-TRFA cultivation for reviving their rice fallows. The table shows that after the intervention, all rabi-cropping farmers were able to cultivate pulses or oilseeds in their fallow lands in 2023-24, indicating the successful implementation of the aforesaid scheme. It is important to note here that only one farmer from one of our sample districts, i.e., South 24-Parganas, cultivated Green Gram (regionally called Mung Bean) in the summer season at his own cost, not under the TRFA scheme, but he sowed grass pea in the rabi season, getting the seed from the TRFA scheme.

Table 5.13: Post-TRFA Cultivation: Respondents reviving Rice Fallow Land

Districts	Yes		No	Total
	Rabi (October to April)	Summer (March to June)		
Birbhum	72	NA	NA	72
South 24-Parganas	72	1	NA	73
Grand Total	144	1	NA	145

Source: Primary survey 2024-25 and authors' Calculation

Table 5.14 below presents the cultivation pattern in 2023-24 on rice-fallow land in two sample districts of West Bengal (Birbhum and South 24 Parganas). In both districts, 72 respondents reported growing first Rabi crops, bringing the total to 144. The average number of second Rabi crops grown is consistent across both districts, with each reporting an average of 1. This scenario indicates that while the adoption of first Rabi crops is relatively widespread, diversification into second Rabi crops remains minimal, suggesting an unchanging pattern of limited crop rotation beyond the first season. The grand total shows that, across the sample districts, farmers tend to grow only one second Rabi crop on average, indicating a trend of limited multi-cropping in their rice-fallow lands.

Table 5.14: Season-wise Cultivation Trends: Respondent Counts & Crop Averages On Rice Fallow Land

Districts	Count of 1^{st} Rabi crops grown	Average of 2^{nd} Rabi crops grown
Birbhum	72	1
South 24-Parganas	72	1
Grand Total	**144**	**1**

Source: Primary survey 2024-25 and authors' Calculation

The data in Table 5.15 represent the impact of the Targeted Rice Fallow Area (TRFA) scheme's initiative in the two sample districts, namely, Birbhum and South 24 Parganas, in West Bengal. Before the launch of the TRFA scheme, the total rice fallow area across the two districts was 62.96 acres, with Birbhum accounting for 37.39 acres and South 24-Parganas for 25.57 acres.

Table 5.15: Impact of the TRFA Scheme

Particulars	Districts	Birbhum	South 24-Parganas	Total
Rice fallow land - After TRFA	First Rabi Crop's Area (in Acres)	22.39	18.49	40.88
	Second Rabi Crop's Area (in Acres)	10.54	0.97	11.51
	First Summer crop's area (in Acres)	NA	0.47	0.47
	Total	**32.9**	**19.93**	**52.83**
	Rice fallow area-Before TRFA (in Acres)	37.39	25.57	62.96
	Reduction in rice fallow area (in Acres)	4.49	5.64	10.13
	Reduction in % (difference between before and after)	**87.99**	**77.94**	**83.91**

Source: Primary survey 2024-25 and authors' Calculation

But after the intervention of the TRFA scheme, this area is reduced to 52.83 acres, resulting in a combined reduction of 10.13 acres of fallow land. Birbhum recorded a decrease of 4.49 acres, whereas South 24-Parganas achieved a slightly higher reduction of 5.64 acres.

At the time of the survey, the fallow lands were effectively utilized for multiple cropping. In Birbhum, 22.39 acres are brought under the first rabi crop, 10.54 acres under the second rabi crop, while South 24-Parganas cultivates 18.49 acres of fallow areas under the first rabi crop, 0.97 acres under the second rabi crop, and 0.47 acres under the first summer crop (only one sample farmer). Overall, 40.88 acres are cultivated with the first rabi crop, 11.51 acres with the second rabi crop, and 0.47 acres with the first summer crop. This transformation reflects a significant decline in rice fallow areas, corresponding to Birbhum achieving an 87.99% reduction and South 24-Parganas recording 77.94%. On average, the two districts together reached an 83.91% reduction.

The figures demonstrate that TRFA has been successful in converting previously uncultivated rice fallow lands into productive agricultural land, thereby increasing overall cultivation among most TRFA beneficiary farmers in these two sample districts. One important thing to note here: this calculation is based only on pulses (chick pea, grass pea, green gram, kheasari bean, lentil, and oilseed, i.e., mustard), as these seeds are distributed in West Bengal under the TRFA scheme. In the latter table, the calculation is considered mostly for cash crops like onion and potato, which are excluded in Table 5.15.

5.5. Cropping Pattern in Rice Fallow Land

The analysis in Table 5.16 is the impact of cultivating paddy on fallow land in West Bengal during the rabi season. The table shows substantial diversification of agricultural practices and a considerable increase in the gross income of sample TRFA beneficiaries. A total of 52.94 acres of rice fallow land was utilized for rabi crops, with farmers opting for a variety of pulses, oilseeds, and vegetables. Chickpea was cultivated on 1.84 acres, yielding an average of 3.90 quintals per acre, while grass pea covered 11.85 acres with a yield of 2.11 quintals per acre. Green gram, though grown on a smaller area of 0.85 acres, produced 3.32 quintals per acre, and khesari bean on 8.43 acres yielded 1.90 quintals per acre. Lentil was one of the major crops, occupying 11.71 acres with a yield of 2.76 quintals per acre, while mustard dominated with 17.64 acres and a yield of 3.39 quintals per acre.

As noted earlier, potatoes and onions are not cultivated using TRFA; these two vegetables are excluded from Table 5.15. However, in Table 5.16 below, vegetables such as onion and potato are considered, though they have a limited area among TRFA beneficiaries. Onion was grown on just 0.05 acres but achieved a remarkable yield of 56 quintals per acre, whereas potato on 0.57 acres produced 52.83 quintals per acre. Despite higher cultivation costs for crops such as onions and potatoes, returns were significant, boosting gross income.

At the time of the survey, the gross income from these crops amounted to ₹7,66,829, with mustard contributing the largest share at ₹3,10,931, followed by lentil at ₹1,78,056 and grass pea at ₹99,807. Even crops grown on smaller plots, such as potatoes and onions, added notable value due to their high yields and market prices. This outcome demonstrates that introducing diverse rabi crops in rice fallow areas not only reduced the extent of uncultivated land but also significantly increased farmers' incomes. The figures emphasize the economic viability of crop diversification in fallow lands and highlight the potential for scaling such interventions to improve rural livelihoods.

Table 5.16: Impact of Cultivating Paddy Fallow Land in West Bengal during the Rabi Season

Crops	Area (in acres) for the Rabi crop in Rice fallow land	Average yield per acre (in quintals) for Rabi crop in Rice Fallow land	Average cost of cultivation per acre (in Rs) for Rabi crop in Rice fallow land	Average price per quintal	Gross income generated
Chick Pea	1.84	3.90	₹ 5,300	₹ 5,250	₹ 37,674
Grass pea	11.85	2.11	₹ 5,276	₹ 4,000	₹ 99,807
Green gram (Mung Bean)	0.85	3.32	₹ 10,500	₹ 7,200	₹ 20,318
Khesari Bean	8.43	1.90	₹ 12,133	₹ 3,350	₹ 53,657
Lentil	11.71	2.76	₹ 14,160	₹ 5,500	₹ 1,78,056
Mustard	17.64	3.39	₹ 8,813	₹ 5,200	₹ 3,10,931
Onion	0.05	56.00	₹ 50,000	₹ 2,200	₹ 6,160
Potato	0.57	52.83	₹ 38,333	₹ 2,000	₹ 60,226
Grand Total	**52.94**				**₹ 7,66,829**

Source: Primary survey 2024-25 and authors' Calculation

Table 5.17: Impact of Cultivating Paddy Fallow Land in West Bengal during the Summer Season

Crop	Area (in acres) for the Rabi crop in Rice fallow land	Average yield per acre (in quintals) for Rabi crop in Rice Fallow land	Average cost of cultivation per acre (in Rs) for Rabi crop in Rice fallow land	Average price per quintal	Gross income increased
Green gram (Mung Bean)	0.47	6.00	₹ 8,000	₹ 6,500	₹ 18,330
Grand Total	**0.47**				**₹ 18,330**

Source: Primary survey 2024-25 and authors' Calculation

Only one farmer from one of our sample districts, i.e., South 24-Parganas, cultivated Green Gram (Colloquially called Mung Bean) in the summer season at his own cost, not under the TRFA scheme, as mentioned earlier. Table 5.17 is the depiction of that particular sample, where it is seen that the area of cultivation is 0.47 acres, the average yield is 6.00 quintals per acre, the average cost he bore was ₹ 8,000 per acre, and at the time of the survey realized price he told me, i.e., ₹ 6,500 (not actual), as the amount produced was not sold. Therefore, the calculation depicts that his income from selling the Green Gram can be increased by ₹ 18,330 at the time of the survey.

5.6. Awareness about Different Governmental Schemes and Farmers' Suggestions

Table 5.18 below highlights awareness of the different governmental schemes. Here, it is evident that most sample farmers are aware of and have benefited from the Targeted Rice Fallow Area (TRFA) scheme under the National Food Security Mission (NFSM). An interesting thing to note here: the remaining 79 sample farmers received awareness from us about the TRFA scheme, and then they could relate to it. But 22 sample farmers were aware but could not cultivate, while 5 sample farmers could not relate to it. So, all these 27 farmers cultivated it at their own cost. They also suggested various reasons, such as untimely seed disbursement, poor seed quality, insufficient seed quantity, and a lack of information, which call for a holistic development of extension services to assess the effectiveness of the schemes they are availing.

Table 5.18: Awareness about Different Governmental Schemes

Sl. No.	Name of the Government Schemes	Aware	Benefitted
1	NFSM and TRFA	32	30
2	NFSM and PM-Kisan	1	1
3	NFSM, TRFA, PMFBY and PM-Kisan	1	1
4	NFSM, TRFA, PMKSY, PMFBY and RKVY	1	1
5	NFSM, TRFA, SHC, PMFBY and PMKSY	1	1
6	NFSM, TRFA, SHC, PMFBY, RKVY and PMKSY	2	2
Total		**38**	**36**

Source: Primary survey 2024-25 and authors' Calculation

Chapter-6: Conclusion and Policy Implications

6.1. Indian Agricultural Scenario

I. Agriculture is still considered a predominant source of livelihood in rural India. Although the Gross Domestic Product (GDP) share of Agriculture and its allied activities was 17.7% at current prices, the employment share across India was 42.3%. Over the past five years, India's agriculture sector has grown at an average annual rate of 4.2%. However, in 2023-24, growth slowed to 1.4%, down from 4.7% in 2022-23. This decline was primarily attributed to reduced food grain production, caused by delayed and erratic monsoons (Economic Survey 2023-24, Govt. of India).

II. Rice fallow land denotes those agricultural fields where rice is cultivated during the Kharif (Monsoon) season, but after that, the cropping land remains uncultivated throughout the Rabi (winter) Season for a period of five years due to some constraints like lack of irrigation facilities, poor soil health, socio-economic factors, etc. These types of land retain residual soil moisture after kharif crop harvesting, which can support the growth of short-duration crops such as Pulses, Oilseeds, and Millets, as well as drought-tolerant crops.

III. Around 28.97 thousand sq. kms. (0.88%) of farmland shifted to fallow land from 2005-06 to 2011-12 under agriculture land. Similarly, around 65.10 thousand sq. kms (1.98%) of fallow land and 9.98 thousand sq. kms of barren or waste lands or uncultivable fallow land and 9.98 thousand sq. kms of barren or waste lands or uncultivable were converted into farmland under agriculture land in the same period.

IV. Although India is a major global producer, its crop yields remain significantly lower than those of other leading agricultural nations due to key structural issues that contribute to low productivity, such as fragmented landholdings, insufficient farm investment, limited mechanisation, and inadequate access to quality inputs (Economic Survey, 2023-24).

6.2. Importance of Remote Sensing and GIS in the Rejuvenation of Fallow Land

I. The study demonstrates that rice fallow dynamics in West Bengal are spatially heterogeneous and shaped by complex interactions among biophysical, socioeconomic, and institutional factors. By integrating remote sensing, GIS and field-level verification, the research distinguishes easily convertible rice fallows from those requiring deeper rehabilitation, and shows that targeted, place-based interventions can convert underutilized post-rice land into productive rabi cropping systems that raise incomes and strengthen local food security.

II. Remote sensing and geographic information systems (GIS) have emerged as indispensable tools in modern agriculture, offering cost-effective and scalable solutions for monitoring, planning and managing crop production (Chavan et al., 2020). These technologies enable the identification of cropping patterns, the development of detailed agricultural land-use databases and interestingly, the spatial mapping of specific crops, including bamboo (Utomowati et al., 2021; Kumar, 2008).

III. By integrating spatial data with ancillary information such as soil profiles, topography, and climatic variables, remote sensing and GIS provide a holistic view of the agricultural landscape. This comprehensive approach supports evidence-based decision-making, enhances resource efficiency and contributes to agricultural sustainability in the long run (Mathenge et al., 2022).

6.3. The Study Findings

I. From secondary data analysis, it is found that the current fallow areas in West Bengal decreased to 244162 hectares in 2020-21 from 348330 hectares in 2000-01. It is also important to note that in our two sample districts (South-24 Parganas and Birbhum), this figure declined significantly (See Appendix, Table A1).

II. It is also seen that through GIS mapping and remote sensing techniques (source: ADRTC, Bengaluru, KSRSAC and ISRO), total fallow land declined to 1951892 hectares in 2023-24 from 2173029 hectares in 2020-21 in West Bengal and from the same source, it is evident that paddy area in West Bengal decreased as well, which is a bit contradictory.

III. A calculation of the change in fallow land from 2020-21 to 2023-24 is made based on the data provided by ADRTC, Bengaluru, KSRSAC and ISRO, where it is found that the reduction of rice fallow land is extensive in Nadia district.

IV. In case of Paddy area in the period 2016-17 to 2022-23, Alipurduar, both Uttar and Dakshin Dinajpur in northern part, South 24-Parganas, Jhargram of southern part of West Bengal has been recorded moderate increase in paddy area (10% to 30%), while Purulia, Nadia, and Howrah are evidenced moderate decline (10% to 30%) in paddy area, while districts like Purba Barddhaman, Purba Medinipur, Hooghly, North 24-Parganas in the southern belt and Maldah, Cooch Behar, Darjeeling, Kalimpong have been recorded slight fall in paddy area (10% or less).

V. The highest increase in rice production (in percentage) has occurred in Alipurduar (46.2%), followed by South-24 Parganas (36.73%) and Jhargram (30.76%), all of which are over 30%. So, in that case, South Bengal is represented by several districts. But it is also notable that Paschim Barddhaman, Murshidabad, and Birbhum experienced the largest decline in rice production (over 30%), underscoring the need for district-centric planning. It is possibly happening due to crop diversification from rice to other crops, as paddy areas have also decreased by over 30 percent in these three districts. So, it can be concluded that, overall, North Bengal is a better performer than South Bengal in terms of the percentage change in rice production during the period 2016-17 to 2022-23.

VI. Districts like Murshidabad, Paschim Barddhaman, and Kalimpong experienced moderate to large declines, while southern and certain eastern districts, including South 24 Parganas, Purba

Medinipur, and Cooch Behar, recorded significant increases. When the mapped categories are read alongside the district-level data, it becomes clear that the most notable gains in yield were achieved in Cooch Behar, Alipurduar, Purba Medinipur, and South 24 Parganas, each registering double-digit growth, with Cooch Behar leading with 18.77 percent. In contrast, Paschim Barddhaman (-14.16%) and Kalimpong (-12.11%) recorded moderate decreases (ranging from 10% to 30%), while Murshidabad and Maldah also showed slightly negative trends, within the 10% range. Several districts, such as Nadia, Birbhum, and Purulia, remained relatively stagnant with negligible changes.

VII. Prior to the Targeted Rice Fallow (TRFA) scheme's implementation, i.e., before 2016-17, all sample households (HH) had fallow land; among them, 80% HH owned fallow land, and the rest had leased-in land, leased out land, including fallow land. But now, after the implementation of the TRFA scheme, all surveyed HHs do not have any current fallow land. It is evident that 35% of farmers received pulse seeds and 65% received Oilseeds in Birbhum (2023-24). In South-24 Parganas, 94% of farmers received pulse seeds, and 6% received Oilseeds.

VIII. Among all sample HH, 35% cultivated oilseeds (Mustard), and the rest 65% cultivated Pulses (Like Masoor, i.e., Lentil, Green Gram or Moong bean, Grass pea, Khesari bean, Chickpea) from respective Agricultural Departments (Under the TRFA scheme).

IX. It is evident that, as per irrigation sources, wells and tube wells were placed first (50.7%), followed by canal irrigation (34.7%), river lifting irrigation (11.1%) and lastly, rainwater harvesting (3.5%).

X. But, looking into several methods of irrigation, most of the farmers (97.9%) are using surface irrigation, followed by drip irrigation (2.1%). There are various methods, including surface irrigation (Flood, Basin, Furrow), well and tube-well (50%), canal irrigation (35%), river lifting irrigation (11%), and rainwater harvesting (4%).

XI. A few questions were asked of sample farmers about the need for any training or capacity building programmes, and it was found that 87.5% of farmers are keen to take this facility, whereas 12.5% are not interested. It is also noted that among these, 87.5% of farmers reported these arrangements in Kharif-June to the Early days of November (52.5%), followed by Rabi-November to March (42%) and Summer-March to June (5.5%). So, it can be prescribed that the potential season is kharif, i.e., the pre-sowing period for Pulses and Oilseeds

XII. It is also asked about the effectiveness of the TRFA scheme, where 83% of farmers preferred it, but 17% of farmers questioned the efficiency of the project.

XIII. Therefore, from farmers' perceptions about the weakness of this TRFA scheme, 61% answered in favour of weakness, along with suggestions, and the remaining 39% did not give any suggestions.

XIV. In case of exploration of non-cultivation of rice fallow land prior to the TRFA period, it is evident that 88 responses have gone to climate vulnerability, followed by water scarcity (73 responses).

XV. The impact of the TRFA scheme's initiative in the two sample districts, i.e., Birbhum and South 24-Parganas districts under West Bengal: before launching the TRFA scheme, the total rice fallow area across the two districts was 62.96 acres, with Birbhum accounting for 37.39 acres and South 24-Parganas for 25.57 acres. But after the intervention of the TRFA scheme, this area is reduced to 52.83 acres in total, resulting in a combined reduction of 10.13 acres of fallow land. Birbhum recorded a decrease of 4.49 acres, whereas South 24-Parganas achieved a slightly higher reduction of 5.64 acres.

6.4. Policy Implications

I. In case of awareness of the different Governmental Schemes, it is seen that most of the sample farmers are aware and have benefited from the Targeted Rice Fallow Area (TRFA) scheme under the National Food Security Mission (NFSM). An interesting thing to note is that the remaining 79 sample farmers got awareness from us about the TRFA scheme, and then they could relate to it. 22 sample farmers were aware but could not cultivate, while 5 could not relate to it. So, all these 27 farmers cultivated it at their own cost. They also suggested various reasons, such as untimely seed disbursement, poor seed quality, insufficient seed quantity, and insufficient information, which call for a holistic development of extension services.

II. Some suggestions were given from farmers' perspective, like regularizing the policy, increasing the seed amount, improving seed quality, timely provision of seeds, mainly before sowing time, creating a soil health testing facility, attaching a training facility, cash benefit or input subsidy is needed, flood management and crop insurance are needed.

III. Deployment of demonstration plots and farmer field schools to show zero-tillage, relay cropping and residue management in local conditions can be introduced. Also, policymakers have to ensure logistics, such as seed distribution calendars tied to sowing windows and mobile advisories, for timely action.

IV. In cases where irrigation facilities are provided, the policy should plan to introduce pond scaling, community recharge structures, repair of minor canals, and low-cost micro-irrigation to enhance residual moisture and enable reliable rabi cropping.

V. Strengthen Farmer-Producer Organizations and accumulate platforms to reduce transaction costs and secure market access for pulses and oilseeds. Introduction of assured procurement windows or price support during the initial scaling phase to support risk management implementation for smallholders. Expand crop insurance and credit products aligned to the rice-fallow calendar and the specific risk profile of second-season crops.

VI. Establishment of district coordination cells that bring together agriculture, water resources, soil health, panchayats and local NGOs to plan, implement and monitor rejuvenation efforts. Ensure participatory planning with farmer groups so that interventions reflect local labour availability, cropping preferences, and socio-economic realities. Alignment of central schemes (TRFA, BGREI, NFSM) with state and district plans to reduce fragmentation and influence co-funding.

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Appendix

Table-A1: Changes in Current Fallow Areas in West Bengal (2000-01 to 2020-21)

(All Figures in Hectares)

Districts	2000-01	2004-05	2008-09	2012-13	2016-17	2020-21
NORTH 24 PARAGANAS	4349	4763	4854	4001	4711	3042
SOUTH 24 PARAGANAS	19187	15285	4632	13101	9157	7387
BANKURA	62144	42684	35887	42208	31168	18254
BIRBHUM	6538	13647	7418	4461	2022	2828
COOCH BEHAR	5635	2195	500	847	800	1518
DARJEELING	8804	13990	17527	16552	12059	6800
DAKSHIN DINAJPUR	1487	3177	1428	10	50	89
UTTAR DINAJPUR	4755	6478	197	144	320	158
HOOGHLY	768	1082	601	667	740	407
HOWRAH	4907	4588	4183	4035	3379	1869
JALPAIGURI	3200	18388	12086	9526	3823	1697
MALDAH	58200	54606	63617	53964	45900	49634
PURBA MEDINIPUR	2457	2106	2886	1160	750	1557
PASCHIM MEDINIPUR	13798	21836	16410	73642	63570	20788
MURSHIDABAD	20567	915	384	495	777	783
NADIA	8530	4294	5048	3434	2452	1407
PURBA BARDHAMAN	9772	7699	6948	3702	1342	505
PURULIA	113232	99252	105534	126363	113111	97294
ALIPURDUAR	0	0	0	0	2277	1672
JHARGRAM	0	0	0	0	0	24715
KALIMPONG	0	0	0	0	0	1598
PASCHIM BARDHAMAN	0	0	0	0	0	160
TOTAL (IN Ha)	**348330**	**316985**	**290140**	**358312**	**298408**	**244162**

Source: DA&FW

Table-A2: Changes in Other than Current Fallow Areas in West Bengal (2000-01 to 2020-21)

(All Figures in Hectares)

Districts	2000-01	2004-05	2008-09	2012-13	2016-17	2020-21
NORTH 24 PARAGANAS	0	0	0	210	40	22
SOUTH 24 PARAGANAS	145	304	204	249	195	253
BANKURA	2351	1881	2054	1078	664	323
BIRBHUM	2567	3360	3945	1315	710	760
COOCH BEHAR	186	347	12	53	0	0
DARJEELING	4009	3489	3754	2934	2341	568
DAKSHIN DINAJPUR	34	119	99	14	81	72
UTTAR DINAJPUR	7	189	39	103	17	4
HOOGHLY	487	549	450	417	0	0
HOWRAH	641	1008	179	135	145	190
JALPAIGURI	248	44	68	118	2	0
MALDAH	259	311	307	304	330	41
PURBA MEDINIPUR	893	118	123	62	16	19
PASCHIM MEDINIPUR	4192	4590	3250	2058	874	303
MURSHIDABAD	92	101	11	113	13	11
NADIA	93	79	81	516	11	14
PURBA BARDHAMAN	5308	4608	1139	1245	160	73
PURULIA	7323	4244	5819	4109	4070	3024
ALIPURDUAR	0	0	0	0	17	8
JHARGRAM	0	0	0	0	0	159
KALIMPONG	0	0	0	0	0	563
PASCHIM BARDHAMAN	0	0	0	0	0	103
TOTAL (IN Ha)	**28835**	**25341**	**21534**	**15033**	**9686**	**6510**

Source: DA&FW

Table-A3: Changes in the Areas Sown More than Once in West Bengal (2000-01 to 2020-21)

(All Figures in Hectares)

Districts	2000-01	2004-05	2008-09	2012-13	2016-17	2020-21
NORTH 24 PARAGANAS	253827	206252	253496	228707	258136	286383
SOUTH 24 PARAGANAS	160497	127044	166256	169628	170387	264972
BANKURA	155170	122338	167581	173112	182525	253917
BIRBHUM	121141	212383	248042	213251	251682	264281
COOCH BEHAR	243511	240419	299921	262066	253332	295655
DARJEELING	49457	32335	61612	59563	64804	27254
DAKSHIN DINAJPUR	108697	122888	141083	116957	117115	238999
UTTAR DINAJPUR	227633	232364	231273	207382	233778	271225
HOOGHLY	165840	300929	339966	315536	301784	307402
HOWRAH	78295	97892	78609	74491	83068	68844
JALPAIGURI	224235	224059	215065	213822	156333	114296
MALDAH	236643	229063	238311	226334	228885	252355
PURBA MEDINIPUR	287913	216396	231955	224910	237907	246149
PASCHIM MEDINIPUR	276395	370449	421725	443680	484327	480450
MURSHIDABAD	361900	553650	538207	518688	584867	538320
NADIA	423135	458192	408060	425005	385110	375391
PURBA BARDHAMAN	311188	379338	409499	323410	282956	358536
PURULIA	13738	22835	56815	57231	46253	83186
ALIPURDUAR	0	0	0	0	49244	83625
JHARGRAM	0	0	0	0		73571
KALIMPONG	0	0	0	0		29301
PASCHIM BARDHAMAN	0	0	0	0		10917
Total (in Ha)	**3699215**	**4148826**	**4507476**	**4253773**	**4372493**	**4925029**

Source: DA&FW

Annexure-1

Rice Fallow Land

Reference Periods: July 2023 to June 2024 (TRFA period) and before TRFA period.

General particulars

Date of interview

yyyy-mm-dd

GPS location

latitude (x.y°)

longitude (x.y°)

altitude (m)

accuracy (m)

Name of the interviewer

Name of the respondent

State

- ◯ Assam
- ◯ Bihar
- ◯ Chhattisgarh
- ◯ Gujarat
- ◯ Jharkhand
- ◯ Karnataka
- ◯ Madhya Pradesh
- ◯ Maharashtra
- ◯ Odisha
- ◯ Tamil Nadu
- ◯ West Bengal

District

Taluk

Hobli/Block

Village name

Is the respondent also the head of the household?

- ◯ Yes
- ◯ No

Gender of the respondent

- ◯ Male
- ◯ Female
- ◯ Trans gender

Contact Number of the respondent

Age of the head

in years

Years of farming experience (Head of household)

____

Education of the head

in years

____

Social category of the respondent

- ○ SC (Scheduled Castes)
- ○ ST (Scheduled Tribes)
- ○ OBC (Other Backward Classes)
- ○ General

Family Type

- ○ Nuclear
- ○ Joint

Household size

____

PDS Card type

1. Antyodaya Anna Yojana (AAY) Ration Card: Issued to the poorest households, providing 35 kg of food grains per month at highly

subsidized rates. 2. Above Poverty Line (APL) Ration Card: Issued to families with income above the poverty line, allowing them to purchase essential commodities at subsidized rates. 3. Below Poverty Line (BPL) Ration Card: Issued to families living below the poverty line, entitling them to 10-20 kg of food grains per month at subsidized rates. 4. Annapurna Yojna (AY) Ration Card: Issued to destitute individuals aged 65 and above, providing 10 kg of food grains per month at no cost.

- ○ Priority Household (PHH) Ration Card
- ○ Antyodaya Anna Yojana (AAY) Ration Card
- ○ Above Poverty Line (APL) Ration Card
- ○ Below Poverty Line (BPL) Ration Card
- ○ Annapurna Yojna (AY) Ration Card

» Operation holding

Please select your type of operational landholding prior to the TRFA period

- ☐ Owned Land
- ☐ Leased-in Land
- ☐ Leased-out Land
- ☐ Fallow land

How much owned land do you have (in acres)?

____

How much leased-in land do you have (in acres)?

____

How much leased-out land do you have (in acres)?

____

How much fallow land do you have (in acres)?

____

»» Irrigated Area Details

Irrigated area (in acres)

____

Major irrigation source

Canal Irrigation: water is transported from a reservoir or river through artificial channels to agricultural fields. Tank Irrigation: storing rainwater in tanks or reservoirs for use during dry periods. Well and Tube Well Irrigation: Utilizes wells or tube wells to extract groundwater for irrigation. River Lift Irrigation: Water is lifted from rivers using pumps and distributed to fields. Rainwater Harvesting: collection and storage of rainwater for various uses, such as irrigation. Traditional Water Harvesting Techniques: Ancient methods of collecting and storing water, often using structures like check dams, ponds, and terraces to capture runoff

- ◯ Canal Irrigation
- ◯ Tank Irrigation
- ◯ Well and Tube Well Irrigation
- ◯ River Lift Irrigation
- ◯ Rainwater Harvesting
- ◯ Traditional Water Harvesting Techniques

Major irrigation method

- ◯ Drip Irrigation
- ◯ Sprinkler Irrigation
- ◯ Surface Irrigation (Flood, Furrow, Basin)
- ◯ Alternate Wetting and Drying (AWD)
- ◯ Manual Irrigation

Cropping pattern- prior to the TRFA period

Which seasons have you cultivated?

- ☐ Kharif (June to October)
- ☐ Rabi (November to February)
- ☐ Summer (March to May)

» Kharif

How many Kharif crops have you grown?

What is the name of the first Kharif crop?

What is the area (in acres) for the first Kharif crop?

What is the production (in quintals) for the first Kharif crop?

What is the price received per quintal (in Rs) for the first Kharif crop?

What is the total by-product value (in Rs) for the first Kharif crop?

What is the name of the second Kharif crop?

What is the area (in acres) for the second Kharif crop?

What is the production (in quintals) for the second Kharif crop?

What is the price received per quintal (in Rs) for the second Kharif crop?

What is the total by-product value (in Rs) for the second Kharif crop?

What is the name of the third Kharif crop?

What is the area (in acres) for the third Kharif crop?

What is the production (in quintals) for the third Kharif crop?

What is the total by-product value (in Rs) for the third Kharif crop?

What is the price received per quintal (in Rs) for the third Kharif crop?

What is the name of the fourth Kharif crop?

What is the area (in acres) for the fourth Kharif crop?

What is the production (in quintals) for the fourth Kharif crop?

What is the total by-product value (in Rs) for the fourth Kharif crop?

What is the price received per quintal (in Rs) for the fourth Kharif crop?

»» Rabi

How many Rabi crops have you grown?

What is the name of the first Rabi crop?

What is the area (in acres) for the first Rabi crop?

What is the production (in quintals) for the first Rabi crop?

What is the price received per quintal (in Rs) for the first Rabi crop?

What is the total by-product value (in Rs) for the first Rabi crop?

What is the name of the second Rabi crop?

What is the area (in acres) for the second Rabi crop?

What is the production (in quintals) for the second Rabi crop?

What is the price received per quintal (in Rs) for the second Rabi crop?

What is the total by-product value (in Rs) for the second Rabi crop?

What is the name of the third Rabi crop?

What is the area (in acres) for the third Rabi crop?

What is the production (in quintals) for the third Rabi crop?

What is the price received per quintal (in Rs) for the third Rabi crop?

What is the total by-product value (in Rs) for the third Rabi crop?

What is the name of the fourth Rabi crop?

What is the area (in acres) for the fourth Rabi crop?

____

What is the production (in quintals) for the fourth Rabi crop?

____

What is the price received per quintal (in Rs) for the fourth Rabi crop?

____

What is the total by-product value (in Rs) for the fourth Rabi crop?

____

»» Summer

How many Summer crops have you grown?

____

What is the name of the first Summer crop?

____

What is the area (in acres) for the first Summer crop?

____

What is the production (in quintals) for the first Summer crop?

____

What is the price received per quintal (in Rs) for the first Summer crop?

____

What is the total by-product value (in Rs) for the first Summer crop?

____

What is the name of the second Summer crop?

____

What is the area (in acres) for the second Summer crop?

____

What is the production (in quintals) for the second Summer crop?

____

What is the price received per quintal (in Rs) for the second Summer crop?

____

What is the total by-product value (in Rs) for the second Summer crop?

____

What is the name of the third Summer crop?

____

What is the area (in acres) for the third Summer crop?

____

What is the production (in quintals) for the third Summer crop?

____

What is the price received per quintal (in Rs) for the third Summer crop?

____

What is the total by-product value (in Rs) for the third Summer crop?

____

Details of Rice Fallow Land

Have you cultivated rice fallow land in the reference year (TRFA period-July 2023 to June 2024)?

- ○ Yes
- ○ No

Which season did you cultivate the rice fallow land in the reference year (TRFA period-July 2023 to June 2024)?

- ☐ Rabi (October to April)
- ☐ Summer (March to June)

How many Rabi crops have you grown in the paddy fallow land?

____

What is the name of the first Rabi crop?

____

What is the area (in acres) for the first Rabi crop?

What is the yield per acre (in quintals) for the first Rabi crop?

What is the cost of cultivation per acre (in Rs) for the first Rabi crop?

What is the name of the second Rabi crop?

What is the area (in acres) for the second Rabi crop?

What is the yield per acre (in quintals) for the second Rabi crop?

What is the cost of cultivation per acre (in Rs) for the second Rabi crop?

What is the name of the third Rabi crop?

What is the area (in acres) for the third Rabi crop?

What is the yield per acre (in quintals) for the third Rabi crop?

What is the cost of cultivation per acre (in Rs) for the third Rabi crop?

How many Summer crops have you grown in the paddy fallow land?

What is the name of the first Summer crop?

What is the area (in acres) for the first Summer crop?

What is the yield per acre (in quintals) for the first Summer crop?

What is the cost of cultivation per acre (in Rs) for the first Summer crop?

____

What is the name of the second Summer crop?

____

What is the area (in acres) for the second Summer crop?

____

What is the yield per acre (in quintals) for the second Summer crop?

____

What is the cost of cultivation per acre (in Rs) for the second Summer crop?

____

What is the name of the third Summer crop?

____

What is the area (in acres) for the third Summer crop?

____

What is the cost of cultivation per acre (in Rs) for the third Summer crop?

____

What is the yield per acre (in quintals) for the third Summer crop?

____

Reasons and Perception for Rice Fallow Land

Major reasons for not cultivating the rice fallow land in prior to TRFA period (multiple select)

- ☐ Low Market Demand: Insufficient demand or low prices for crop made cultivation economically unviable.
- ☐ Water Scarcity: Limited water availability or unreliable irrigation infrastructure hinder rice cultivation.
- ☐ Labor Intensity: Crop cultivation required significant manual labour, which was costly/ unavailable.
- ☐ Soil Health Concerns: Prioritized fallow periods to restore soil fertility and structure.
- ☐ Climate Vulnerability: Risks associated with climate change/variability, such as droughts or floods, made crop cultivation risky.
- ☐ Input Costs: High input costs, including seeds, fertilizers, and pesticides, out-weighted potential returns.
- ☐ Market Access Issues: Limited access to markets or transportation challenges hindered rice sales.
- ☐ Government Policies: Government regulations or subsidies favoured other crops or land uses over rice cultivation.
- ☐ Land Health issues: Salinity, alkalinity, etc.
- ☐ Any other issues not mentioned above: (Please mention)

Please specify the reason for not cultivating the rice fallow land (if you click 'Any other issues not mentioned above')

____

Out of the above selected options for not cultivating the rice fallow land, which is the top reason?

____

» Perception

Perception perceived by farmers on Rice Fallow Land cultivation (after TRFA period)

____

1st choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

2nd choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

3rd choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

4th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

5th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

6th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

7th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

8th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

9th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

10th choice

- ◯ Water Availability: Adequate water supply is crucial for successful cultivation.
- ◯ Soil Fertility: Fertile soil is essential for healthy crop growth and higher yields.
- ◯ Land Suitability: Proper assessment of land suitability ensures optimal crop growth.
- ◯ Seed Quality: High-quality seeds lead to better germination rates and stronger plants.
- ◯ Disease Prevention: Measures to prevent diseases are vital for maintaining crop health.
- ◯ Irrigation Methods: Efficient irrigation methods help conserve water and maximize yields.
- ◯ Fertilization: Proper fertilization ensures plants receive essential nutrients for growth
- ◯ Market Knowledge: Understanding market demands helps in strategic planning and maximizing profits.
- ◯ Community Support: Access to resources, knowledge, and shared experiences enhances overall farming success.
- ◯ Pest Management: Effective pest control is necessary to protect crops from damage.

Knowledge and Awareness

Are you aware of government schemes or programs related to rejuvenating fallow land?

- ◯ Yes
- ◯ No

If Yes, mention the schemes you are aware of

- ☐ National Food Security Mission (NFSM) includes Targeting Rice Fallow Area (TRFA)
- ☐ National Mission for Sustainable Agriculture (NMSA)
- ☐ Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)
- ☐ Rashtriya Krishi Vikas Yojana (RKVY)
- ☐ Paramparagat Krishi Vikas Yojana (PKVY)
- ☐ National Watershed Development Project for Rainfed Areas (NWDPRA)
- ☐ Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)
- ☐ Soil Health Card Scheme
- ☐ National Bamboo Mission
- ☐ Pradhan Mantri Fasal Bima Yojana (PMFBY)
- ☐ Comprehensive Project on Rice Fallow Management
- ☐ Integrated Watershed Management Programme (IWMP)
- ☐ Other (please specify)

Please specify the scheme which you are aware of (if you click 'Other')

____

Are you benefiting from any programs aimed at rejuvenating rice fallow land?

- ◯ Yes
- ◯ No

If you are a beneficiary, kindly select the scheme/programme you have benefitted

- ☐ National Food Security Mission (NFSM) includes Targeting Rice Fallow Area (TRFA)
- ☐ National Mission for Sustainable Agriculture (NMSA)
- ☐ Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)
- ☐ Rashtriya Krishi Vikas Yojana (RKVY)
- ☐ Paramparagat Krishi Vikas Yojana (PKVY)
- ☐ National Watershed Development Project for Rainfed Areas (NWDPRA)
- ☐ Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)
- ☐ Soil Health Card Scheme
- ☐ National Bamboo Mission
- ☐ Pradhan Mantri Fasal Bima Yojana (PMFBY)
- ☐ Comprehensive Project on Rice Fallow Management
- ☐ Integrated Watershed Management Programme (IWMP)
- ☐ Other (please specify)

Please specify the scheme which you are benefited/ benefiting of (if you click 'Other')

____

Did the programme implemented by the government help you to rejuvenate your rice fallow land?

○ Yes

○ No

If yes, provide the detail (Rejuvenation of the rice fallow land in acres)

____

Do you think, providing training/ capacity building helps in rejuvenating the fallow land and cultivate crops?

1. National Food Security Mission (NFSM) includes Targeting Rice Fallow Area (TRFA) 2. National Mission for Sustainable Agriculture (NMSA)

3. Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) 4. Rashtriya Krishi Vikas Yojana (RKVY) 5. Paramparagat Krishi Vikas Yojana (PKVY) 6.

National Watershed Development Project for Rainfed Areas (NWDPRA) 7. Mahatma Gandhi National Rural Employment Guarantee Act

(MGNREGA) 8. Soil Health Card Scheme 9. National Bamboo Mission 10. Pradhan Mantri Fasal Bima Yojana (PMFBY) 11. Comprehensive Project on Rice Fallow Management 12. Integrated Watershed Management Programme (IWMP)

○ Yes

○ No

If Yes, provide the details of training required and the preference of season for the training: ○ Kharif-June-Early days of November ; ○ Rabi-November-March: ○ Zaid-March-June

Suggestion and feedback

Do you think the existing programs/policies on rejuvenating fallow lands in your area are effective?

Yes

No

Do you believe the current programs/policies have strengths or positive aspects in promoting cultivation on rice fallow lands? Yes No

Do you see any weaknesses in the current policies that may hinder the promotion of cultivation on rice fallow lands?

Yes

No

If yes, kindly provide the details

Do you think there is a need for new policies or modifications to existing ones?

Yes

No

If yes, please specify

Any suggestions you would like give regarding the impact of policies on fallow land rejuvenation?

Please attach an image of the respondent with the fallow land, including GPS coordinates (take a picture from GPS Map camera and upload it)

Although the fallow land is being cultivated this season, please attach an image for ground proofing

Click here to upload file. (< 10MB)

Annexure-2

Formal Review Report by the Co-ordinator (ADRTC, ISEC) of the Study and Actions Taken

Title of The Report		Rejuvenating Rice Fallow Lands in West Bengal Using Remote Sensing and GIS.
Date of Receipt of the comments		04.06.2026
Suggestions		**Actions Taken**
1.	Acknowledgment should be included before the Table of Contents	Acknowledgement is included in the last two paragraphs of the Preface
2.	Central Project Citation Correction	Citation of the central project co-ordinator is revised and corrected
3.	Rewriting of the Objectives of the Study for clarity and specificity	Revised and rewritten for clarity and specificity, both in the executive summary and introduction (Chapter-1)
4.	The third objective states the use of both Chi-square test and Garrett Ranking, but analysis predominantly reflects Garrett Ranking (perceptions)	For Perceptions, the Garrett Ranking has been used. For Reasons/determinants, Chi-square analysis is used. The purpose of using the two methodologies is clearly distinguished in Chpater-2 (Methodology)
5.	Add Legend, Scale and North arrow within the map for better understanding of the results for the reader in Figure 3.3: Mapping of Percentage Change in Rice Fallow Land from 2020-21 to 2023-24 & Figure 3.4: Mapping of Change in Current Rice Fallow Land from 2000-01 to 2020-21.	Everything is described and written in the colours
6.	Keep Scale left side and Legend right side of the map in Figure 3.5: Mapping Paddy Area in 2020-21& Figure 3.6: Mapping Paddy Area in 2023-24	These mappings were provided by ADRTC, ISEC, Bengaluru (The central project Co-ordinator)
7.	Add scale and North Arrow in Figure 4.1: Mapping of District-wise Percentage Change in Paddy Area from 2016-17 to 2022-23 & Figure 4.3: Mapping of District-wise Percentage Change in Rice Production from 2016-17 to 2022-23 & Figure 4.5: Mapping of District-wise Percentage Change in Yield of Paddy from 2016-17 to 2022-23	Everything is described and written in the colours
8.	Farmer perceptions are well analysed through Garrett Ranking. However, reasons for non-cultivation are less explicitly addressed.	The reasons for non-cultivation have been clearly addressed in Chapter 5, Section 5.2.

Suggestions		Actions Taken
9.	Inclusion of references: Economic Survey 2023-24, Government of India; Sharma et al., 2016	Included in References
10.	Limit to 4-5 specific, evidence-based recommendations	The evidence-based recommendations have been reduced both in the executive summary and policy implications (Chapter-6)
11.	Annexure Revision: Replace the typed questionnaire with the KOBO-based questionnaire	Replaced
12.	A complete review of the reference list is recommended to ensure Consistency, Completeness and Proper citation format	The reference list has been revised per the suggestions.
13.	The Executive Summary should clearly and concisely highlight the status of Fallow land as a whole, and the reasons and perceptions of the selected farmers for not cultivating these rice fallow lands, and the impact of existing policies and programmes with respect to fallow land, especially the TRFA program’s impact, since this was evaluated for the study	Revised. The suggestions are mentioned in the Major Findings
14.	Recommended for acceptance with minor to moderate revisions	Revised as per the recommendations of the central project Co-ordinator

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