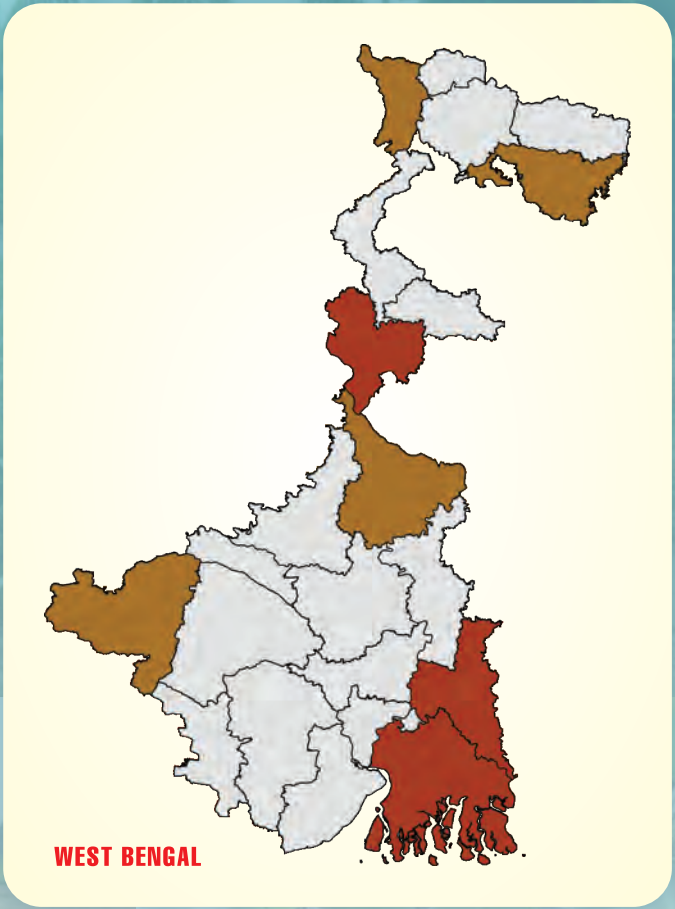
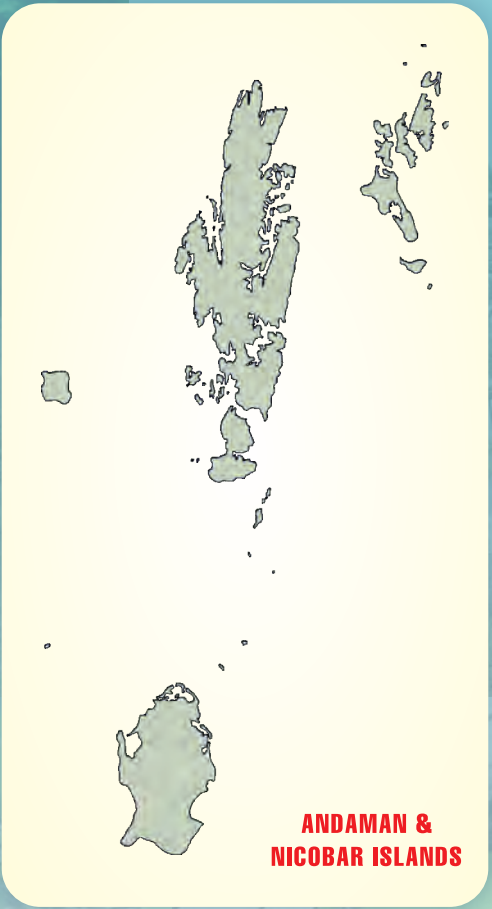
Promising Climate Resilient Technologies for

WEST BENGAL and ANDAMAN & NICOBAR ISLANDS











National Innovations in Climate Resilient Agriculture
ICAR-Central Research Institute for Dryland Agriculture, Hyderabad
ICAR-Agricultural Technology Application Research Institute, Kolkata
Natural Resource Management & Agricultural Extension Divisions
Indian Council of Agricultural Research (ICAR), New Delhi

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24.10.2025

Foreword

In today's rapidly changing world, the effects of climate change are increasingly evident, drawing attention to the need for resilient agricultural technologies. India, with its diverse landscapes and climates, is highly vulnerable due to its dependence on agriculture. To strengthen the country's capacity to cope with climatic challenges, the Indian Council of Agricultural Research launched the National Innovations in Climate Resilient Agriculture (NICRA) programme in 2011. A major component of this initiative, the Technology Demonstration Component (TDC), focuses on participatory on-farm demonstrations of proven climate-resilient technologies.

West Bengal, with its varied terrain and climatic conditions, is among the states actively addressing climate challenges. The Andaman and Nicobar Islands, with their unique climate and topography, face similar vulnerabilities. Under TDC-NICRA, seven districts of West Bengal—Cooch Behar, Darjeeling, Malda, Murshidabad, North 24 Parganas, Purulia, and South 24 Parganas—and one district from the Andaman and Nicobar Islands (South Andaman) were selected for implementation. These regions, frequently affected by cyclones, floods, high rainfall, and moisture stress, are increasingly exposed to erratic weather and water scarcity.

This publication, "Promising Climate Resilient Technologies for West Bengal and Andaman & Nicobar Islands," showcases successful interventions introduced under TDC-NICRA. The demonstrated technologies include improved crop varieties, efficient water and soil management, livestock management, and sustainable farming practices. Field demonstrations and research have identified key technologies that can mitigate climatic stresses while enhancing productivity and sustainability. Village-level institutions such as Village Climate Risk Management Committees (VCRMCs), Custom Hiring Centres (CHCs), and seed and fodder banks have also been established to support farmers and promote wider adoption.

I commend the authors for compiling this valuable publication and appreciate the efforts of participating institutions and farmers from NICRA villages. I am confident that these technologies will be effectively integrated into the developmental programmes of West Bengal and the Andaman & Nicobar Islands, contributing to more climate-resilient agriculture in the region.

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PREFACE

Welcome to the world of innovation and resilience. In this book, "Promising Climate Resilient Technologies for West Bengal", we embark on a journey through innovative solutions drafted to address the challenges of climate change. The Technology Demonstration Component (TDC) of National Innovations in Climate Resilient Agriculture (NICRA) aims at identifying climate resilient technologies in partnership with the farming community to build resilience of farmers so as to enhance their adaptive capacity to the climate vulnerabilities.

Various promising technologies pertinent to natural resource management, crops, cropping systems and livestock were demonstrated with active participation of farmers. Village level institutions such as seed banks, fodder banks, custom hiring centers (CHCs), village climate risk management committees (VCRMCs) were established in the NICRA villages. The technologies which were found to be promising are compiled along with economics during stress and normal years. The upscaling domains for each technology were indicated and the possible development programmes were identified. The proven resilient practices were scaled up in convergence with various ongoing developmental programmes of the states.

We take this opportunity to gratefully acknowledge the constant guidance and support from Dr. Mangi Lal Jat, Secretary (DARE) & Director General (ICAR), members of the high-level monitoring committee, chairmen and members of zonal monitoring committee, directors of extension of the state agricultural and veterinary universities, officials of development departments and KVKs of the state. We gratefully acknowledge the valuable contribution of farmers, VCRMC members and other stakeholders of the project.

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LIST OF ACRONYMS

ATMA	Agricultural Technology Management Agency
BCR	Benefit Cost Ratio
CFLDs	Cluster Frontline Demonstrations
CGWB	Central Ground Water Board
CHC	Custom Hiring Centre
DWMA	District Water Management Agency
FPO	Farmer Producer Organization
ICAR	Indian Council of Agricultural Research
IFS	Integrated Farming System
IWMP	Integrated Watershed Management Programme
KVK	Krishi Vigyan Kendra
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee scheme
MIDH	Mission for Integrated Development of Horticulture
NABARD	National Bank for Agriculture and Rural Development
NDDB	National Dairy Development Board
NFSM	National Food Security Mission
NGO	Non-Government Organization
NHM	National Horticulture Mission
NICRA	National Innovations in Climate Resilient Agriculture
NMSA	National Mission for Sustainable Agriculture
NRM	National Resource Management
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PKVY	Paramparagat Krishi Vikas Yojana
RKVY	Rastriya Krishi Vikas Yojana
SAUs	State Agricultural Universities
SFAC	Small Farmers' Agri-Business Consortium
TDC	Technology Demonstration Component
VCRMC	Village Climate Risk Management Committee

1. INTRODUCTION

1. Introduction

West Bengal is one of the eastern states of India, which lies between 20°30' to 27°16' N latitudes and 85°50' to 89°52' E longitudes and covers an area of 88,752 sq km. It is the twelfth largest state in terms of area in Indian union located in the eastern part of the country stretching from the Himalayas in the north to the Bay of Bengal in the south. The state has international boundaries with Bangladesh in the east, Bhutan and Nepal in the north. The state is bounded on the north by Sikkim and Bhutan, on south by Bay of Bengal, on east by Assam and Bangladesh and on the west by Orissa, Jharkhand, Bihar and Nepal. West Bengal has four major geographical regions - the Chotanagpur plateau region in its northwestern parts, the Himalayan mountain region, the lower Gangetic plain region and the coastal belt. Bhagirathi, Mayurakshi, Damodar, Kangsabati, Teesta, Torsha, Jaldhaka, Mahananda, Subarnarekha and Rupnarayan are the main rivers of this state. There are forest areas in the southern part (Sunderbans), northern Tarai belt and in the plateau area of the state. The entire state belongs to a high rainfall region. Most of the rainfall (74-83%) is by the southwest monsoon. Based on rainfall distribution, irrigation pattern, cropping pattern, soil characteristics and other physical, ecological and social characteristics, West Bengal is classified into six distinct agro-climatic zones. The maximum elevation of the state is 3636 m with a minimum elevation of 11 m and an average elevation of 500 m from MSL. The geographical area of West Bengal has been classified according to different types of land use as presented in the chart below (fig. 1&2). The predominant soils of West Bengal are Ultisols, Alfisols, *Inceptisols* and Entisols.

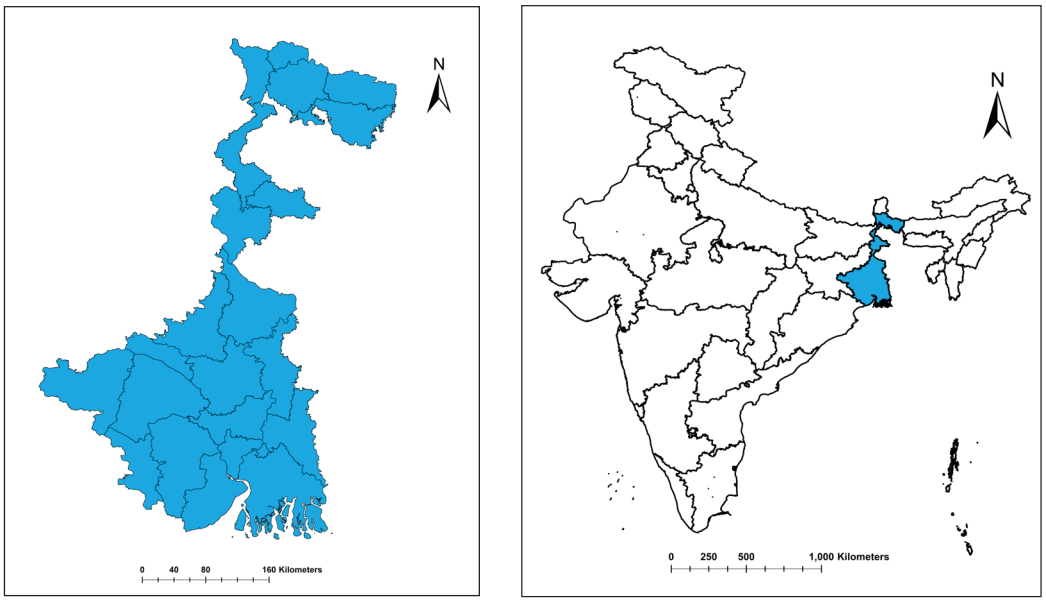


Fig. 1&2 : Geographical area of West Bengal

Andaman and Nicobar Islands is a union territory of India, which lies between 6°45' N to 13°41' N latitudes and 92°12' E to 93°57' E longitudes and covers an area of 8,249 sq km. It is the largest union territory in terms of area, located in the south-eastern part of the Bay of Bengal. The territory consists of 572 islands, out of which about 31 are inhabited, stretching in a north-south direction for about 800 km.

The territory has international maritime boundaries with Thailand and Myanmar to the east, and it is geographically closer to Indonesia and Myanmar than to mainland India. The Andaman Islands lie north of the Ten Degree Channel and the Nicobar Islands lie to its south. The Andaman Sea lies to the east of the islands while the Bay of Bengal lies to the west.

Andaman and Nicobar Islands have four major geographical regions – the North Andaman, Middle Andaman, South Andaman, and Nicobar Islands. Although Andaman and Nicobar Islands do not have large river systems like mainland India, small rivers such as Kalpong in North Andaman and Alexandra, Amrit Kaur, Galathea and Dagmar in Great Nicobar along with numerous perennial streams and creeks, drain these islands. Mount Harriet, Saddle Peak (732 m, the highest point in North Andaman), and Mount Thullier (642 m, the highest in Great Nicobar) are important elevated features of the territory. The islands are predominantly covered with tropical evergreen forests, mangroves, and coastal forests. The Great Nicobar Biosphere Reserve and North Button, South Button, and Middle Button National Parks are major ecological reserves.

The entire territory receives high rainfall, with most of the rainfall (approximately 80-85%) occurring due to the southwest and northeast monsoons. Based on rainfall pattern, cropping systems, soil characteristics, topography, and ecological conditions, Andaman and Nicobar Islands are classified into two agro-climatic zones: Andaman group and Nicobar group. The maximum elevation in the islands is 732 m (Saddle Peak in North Andaman) with a minimum elevation at sea level, and an average elevation around 200 m from MSL. The geographical area of Andaman and Nicobar Islands has been classified according to different types of land use such as forest cover (which constitutes more than 80% of total area), agriculture, settlements, and coastal areas. The predominant soils of Andaman and Nicobar Islands are Entisols, Inceptisols, and Ultisols, generally rich in organic matter but acidic in nature.

Climate of West Bengal

The climate of West Bengal varies from tropical savanna in the southern portions to humid subtropical in the north and the temperature ranges between 8.4°C and 37°C. The state is divided into six agro-climatic zones for planning and agricultural development. The relative humidity is generally high during the period from July to September. It is about 80% in June rising to about 83% to 85% in July, August and September. The total annual rainfall in the plains of the state increases from 142 cm over the southern parts to 371 cm towards the northern parts, while it is 116 cm over the northwestern parts of Gangetic West Bengal. The foothills of Himalayas receive maximum amount of annual rainfall ranging from 205 to 450 cm. The southwest monsoon is the major source of rainfall. The plains of the state receive almost 74% to 83% of annual rainfall, whereas the hills of West Bengal receive 73% to 87% during south west monsoon.

Climate of Andaman and Nicobar Islands

The Andaman & Nicobar Islands are situated in the equatorial belt and exposed to marine influences and have a tropical climate, warm, moist and equable. The temperature ranges from 22˚C to 32˚C. The average annual rainfall ranges from 3,000 to 3,500mm and humidity varies from 66 to 85 percent. Normally the average rainfall received during May to December is 2250 mm in

May-September during southwest monsoon and 685 mm in October-December during northeast monsoon and remaining 65 mm – 565 mm occurs during January-April. This is the dry period and the numbers of rainy day in these four months does not exceed three days per month. Agricultural crops suffer badly during this period due to moisture stress. In some years the Islands have experienced rains during all the months of the year, Cyclone occur during the monsoons, accompanied by very strong winds mainly during May and November and in some years during mid-April.

Cropping pattern in West Bengal

Cropping pattern is defined as the spatial representation of crops rotations, or as the list of crops that are being produced in an area and their sequence in time. Agriculture is the backbone of West Bengal. The cultivated area of the state is 5.5 million ha comprising 62% of the total geographical area. About 54% of cultivated area is irrigated and the cropping intensity is 176%. Nearly 39% of the total population of the state depends directly or indirectly on farming. Rice is the most important *kharif* crop, which presently accounts for 77% of the total rice area and 68% of total area is under food grains in the state. In addition, wheat, pulses, mustard, groundnut, jute, sugarcane, potato, fruits, vegetables and flowers are cultivated.

Cropping pattern in Andaman and Nicobar Islands

Cropping pattern is defined as the spatial representation of crop rotations or as the list of crops that are being produced in an area and their sequence in time. Agriculture is an important sector of Andaman and Nicobar Islands, with a cultivated area of approximately 47,000 ha, comprising 5.7% of its total geographical area. About 15% of the cultivated area is irrigated and the cropping intensity is 126%. Nearly 50% of the rural population depends directly or indirectly on agriculture. Rice is the predominant crop, accounting for about 60% of the gross cropped area. In addition, pulses, oilseeds (mustard, sesame), coconut, arecanut, rubber, fruits, vegetables, tuber crops, and spices are cultivated in these islands.

1.1 Climate change in West Bengal and Andaman & Nicobar Islands

Erratic rainfall due to climate change is also compounding the challenge. There is high surface run off in western zone leading to soil erosion while the coastal area suffers from saline water ingress and limited ground water aquifer. West Bengal has taken up a project for enhancement of agricultural productivities in different districts including rainfed regions and coastal belt to beat the three-pronged challenges of rising population, declining water reserves and climate change.

Intelligent interventions in form of minor irrigation and well thought innovative intercropping/ plantation have significantly improved the socioeconomic conditions of farmers and reduce their vulnerability in project area.

Climate change is severely affecting Andaman and Nicobar Islands, with rising temperatures (0.5–0.8°C increase), erratic rainfall, frequent dry spells, and increased cyclonic activity. The sea level rise (~2.8 mm/year) is leading to coastal erosion, saline water intrusion, and submergence of low-lying agricultural lands, particularly in Nicobar districts. Extreme events such as cyclones and storm surges damage crops, plantations, and fisheries infrastructure, while soil salinization renders paddy lands unproductive. Additionally, climate change is threatening the islands' rich biodiversity, coral reefs, and mangrove ecosystems, while fisheries are affected due to altered sea surface temperatures and breeding patterns.

1.2 Challenges to West Bengal and Andaman & Nicobar Islands in the context of climate change

Agriculture is highly susceptible to climate change and global warming. A slight change in climatic factors can significantly affect the agricultural production. Countries highly dependent on agriculture like India are highly vulnerable to climate change. West Bengal is contributing 5.7% of the total food grain production in the country, which is 24% higher than the country's average. The state has 54% of its total cultivated area under irrigation. Climate vulnerabilities in the state range from moisture stress to high rainfall, flood and cyclone which led to widespread crop damage and loss of agricultural productivity in the recent times. Climate change in terms of changing temperatures, rainfall variability, and extreme weather events can significantly impact agriculture in West Bengal. Increased frequency and/or intensity of events like high rainfall, cyclones and floods can lead not only to crop damage but also to waterlogging and soil erosion. Some of the adaptation strategies needed for current climate change scenario are i) Crop diversification: Selection of crops that can adapt or suitable to changing climate conditions can reduce risks associated with highly sensitive crops. ii) Water management: Improved water management practices like rainwater harvesting, *in-situ* moisture conservation, efficient irrigation techniques, and water storage, can address water scarcity issues. iii) Climate-resilient crop varieties: Cultivation of climate-resilient crop varieties can enhance the adaptability of agriculture to changing climatic conditions. Different crops respond differently to climate change. Changes in temperature and precipitation patterns may affect the suitability of certain crops for specific regions. Farmers face challenges in adapting to these changes due to limited access to resources, technology, and support systems. The transition to climate-resilient crops and practices requires significant investment, support and knowledge. The impact of climate change varies across different agro-climatic zones in West Bengal, with some regions being more vulnerable than others. Addressing these challenges requires a combination of technological solutions, policy support, and community-based adaptation strategies.

Agriculture in Andaman and Nicobar Islands is highly vulnerable to climate change impacts such as rising temperatures, erratic rainfall patterns, cyclones, sea level rise, and saltwater intrusion. These factors pose significant threats to crop yields, particularly rice and plantation crops, and challenge the islands' food self-sufficiency due to their reliance on imports from mainland India. To address these vulnerabilities, it is essential to promote diversification towards climate-resilient crops, adoption of efficient water management practices like rainwater harvesting and micro-irrigation, integrated farming systems, and establishment of coastal bio-shields. Farmers often find it difficult to implement these measures because of limited technical knowledge, inadequate infrastructure, and restricted market access. Therefore, strengthening institutional support, facilitating technology transfer, and ensuring community participation are crucial steps to build a more climate-resilient and sustainable agricultural system in the islands.

1.3 Overview of the agro-ecosystems and predominant production systems in the selected districts under NICRA

West Bengal is divided into 6 agro-climatic zones based on the extent and distribution of rainfall, soil characters, elevation, topography, vegetation and major crops.

Northern hill zone (Zone I): Annual rainfall of the zone is 2500 to 3500 mm, brown forest and tarai soils are the major soil types of the zone. Maize, potato, cabbage, cauliflower, pea, bean etc. are the major crops grown in the region.

Teesta-tarai alluvial zone (Zone II): Annual rainfall of the zone is 2000 to 3000 mm, tarai soils and sandy loam alluvial soils are the major soil types. Important crops grown in the region are potato, tomato, cabbage, cauliflower, brinjal, spinach etc.

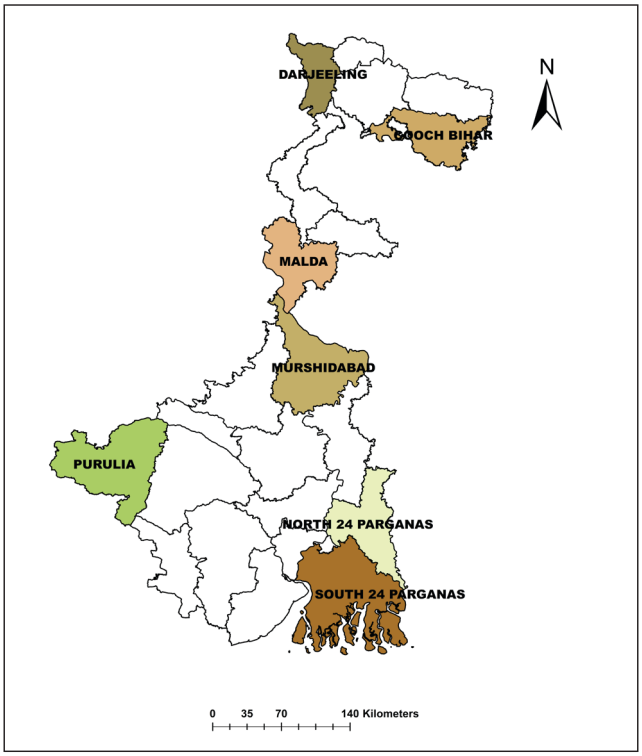
Gangetic alluvial zone (Zone III): Annual rainfall of the zone is 1350 to 1650 mm, fertile loam, clay loam and clayey soils are the major soil types. Rice, lentil, sugarcane, mustard, sesame, jute, potato etc. are the major crops grown in the region.

Vindhyan alluvial zone (Zone IV): Annual rainfall of the zone is 1500 to 2000 mm, sandy loam, clay loam and loam soils are the major soil types. Important crops grown in the region are rice, lentil, mustard, groundnut, potato, egg plant etc.

Coastal saline zone (Zone V): Annual rainfall of the zone is 1600 to 1800 mm, sandy loam, loam type of saline alluvial soils are the major soil types. Rice, mustard, knolkhol, arum, chilli, potato, spinach etc. are the major crops grown in the region.

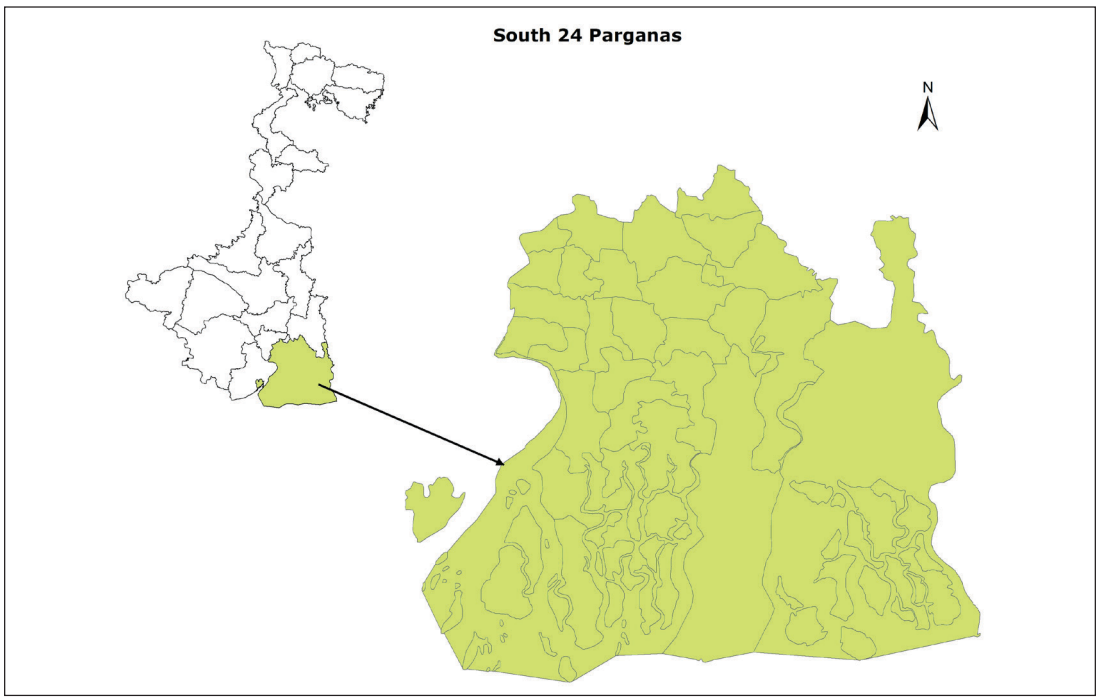
Red and laterite zone (Zone VI): Annual rainfall of the zone is 1100 to 1400 mm; red lateritic and gravelly soils are the major soil types. Important crops grown in the region are rice, maize, potato, tomato, cucurbits, okra, arum etc.

Following districts were selected as a vulnerable districts under NICRA.



1.3.1 South 24 Parganas

South 24 Parganas district is located between 21° 95' N latitude to 88° 33' E longitude with an elevation of 7 m above MSL. The district falls under Eastern coastal plain, hot sub humid to semi-arid eco sub region of the agro-eco sub region 18.5; Assam and Bengal plain, hot sub humid to humid (inclusion of per humid) eco sub region eco sub region of the agro-eco sub region 15.1 (ICAR). It is classified under lower Gangetic Plain region (III) of agro-climatic zoning of planning commission and under coastal saline zone (WB-6) of agro-climatic zoning of NARP. The



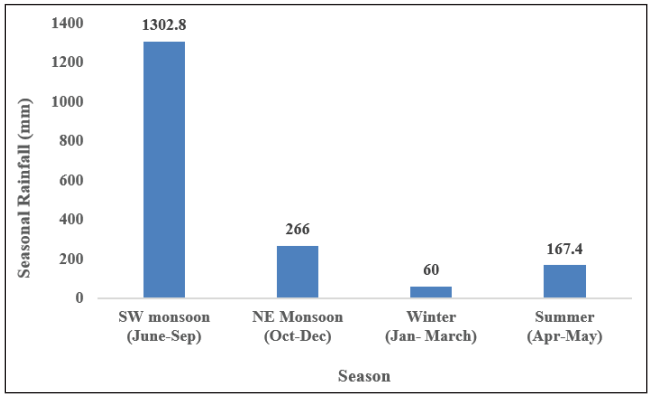


Fig. 3 : Season-wise rainfall (mm)

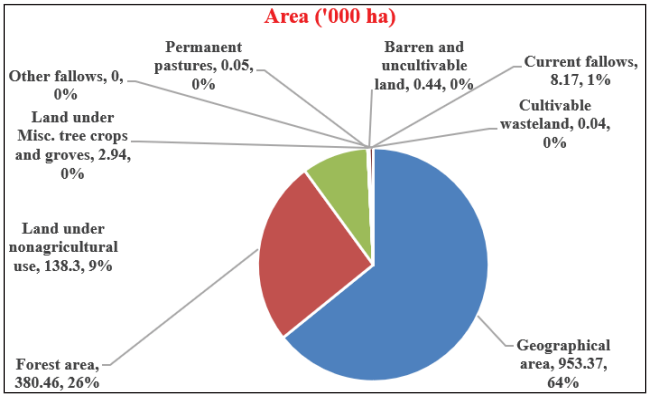
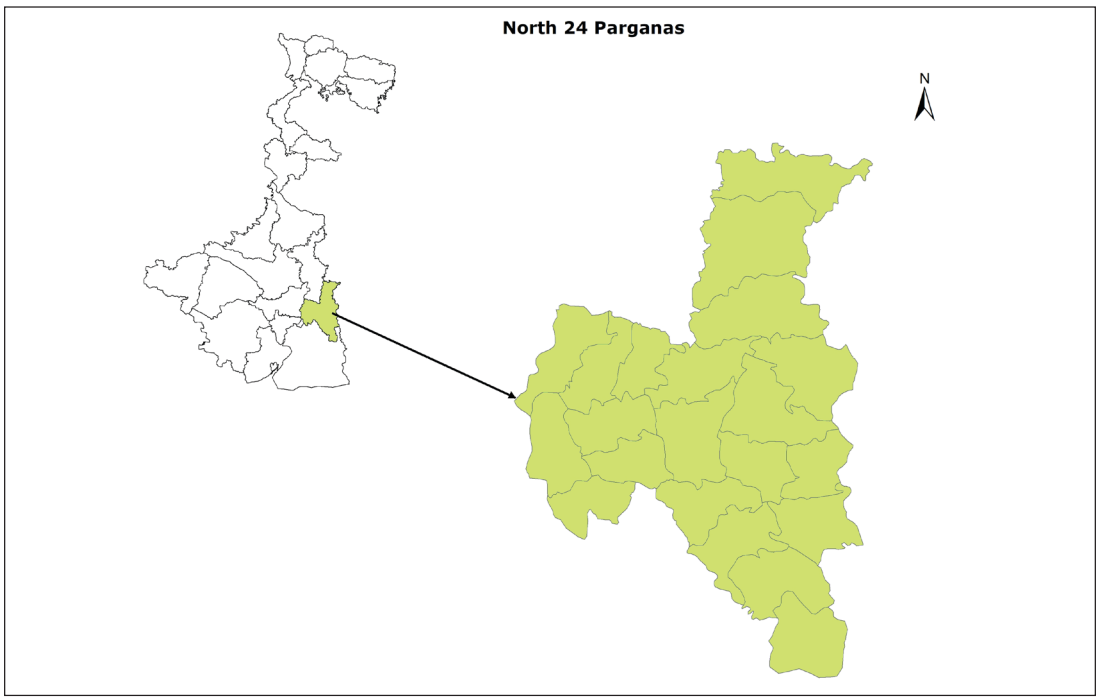


Fig. 4 : Land use pattern of South 24 Parganas

geographical area of the district is 9.53 lakh ha, out of which cultivable area is 3.80 lakh ha and forest area is 4.26 lakh ha (Fig. 4). The gross cropped area of the district is 5.31 lakh ha, out of which 3.72 lakh ha is net sown area and 1.58 lakh ha area is double cropped area. The area under rainfed condition is 2.56 lakh ha and under irrigation is 5.31 lakh ha. The major source of irrigation in the district are canals, borewells, tanks and other sources. The major crops grown in the district include rice, wheat, pulses, oilseeds, chilli, potato and fruit crops like mango, banana, papaya, guava, litchi and vegetable crops like brinjal, lady's finger, cabbage, cauliflower and tomato. Indigenous cattle, crossbred cattle, indigenous buffaloes, graded buffaloes, goat and sheep farming is widely practiced in the district. The average annual rainfall of the district is 1796 mm and 72 % of the rainfall is received in *kharif* (Fig. 3). The predominant soils in the district are loamy, clay loamy and clayey soils.

1.3.2 North 24 Parganas

North 24 Parganas district is located between 22° 36' N latitude to 88° 39' E longitude with an elevation of 8 m above MSL. The district is categorized into Bengal and Assam plains, hot sub



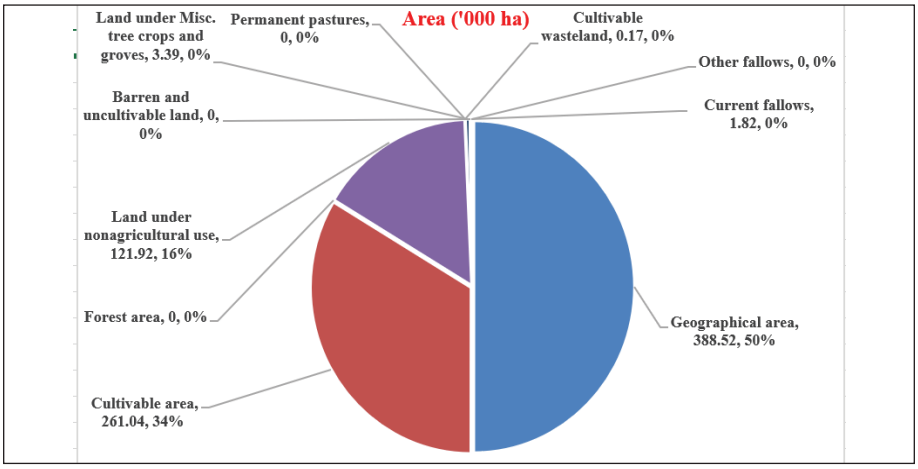


Fig. 5 : Major soil classification

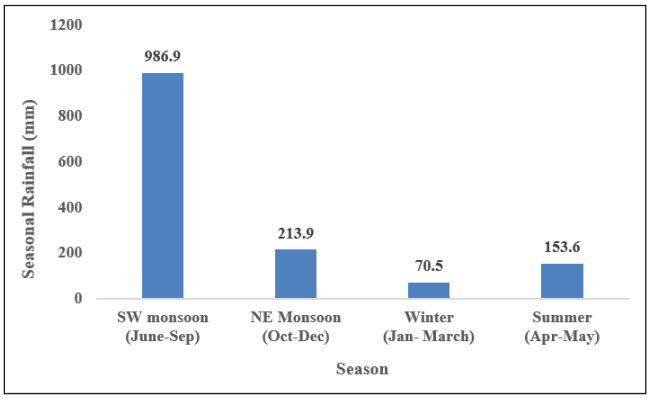


Fig. 6 : Season-wise rainfall (mm)

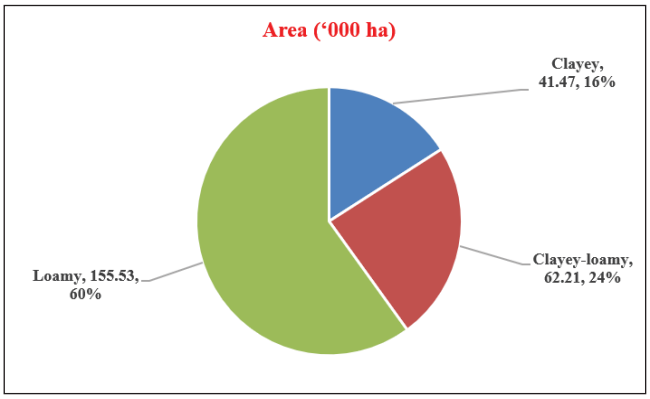
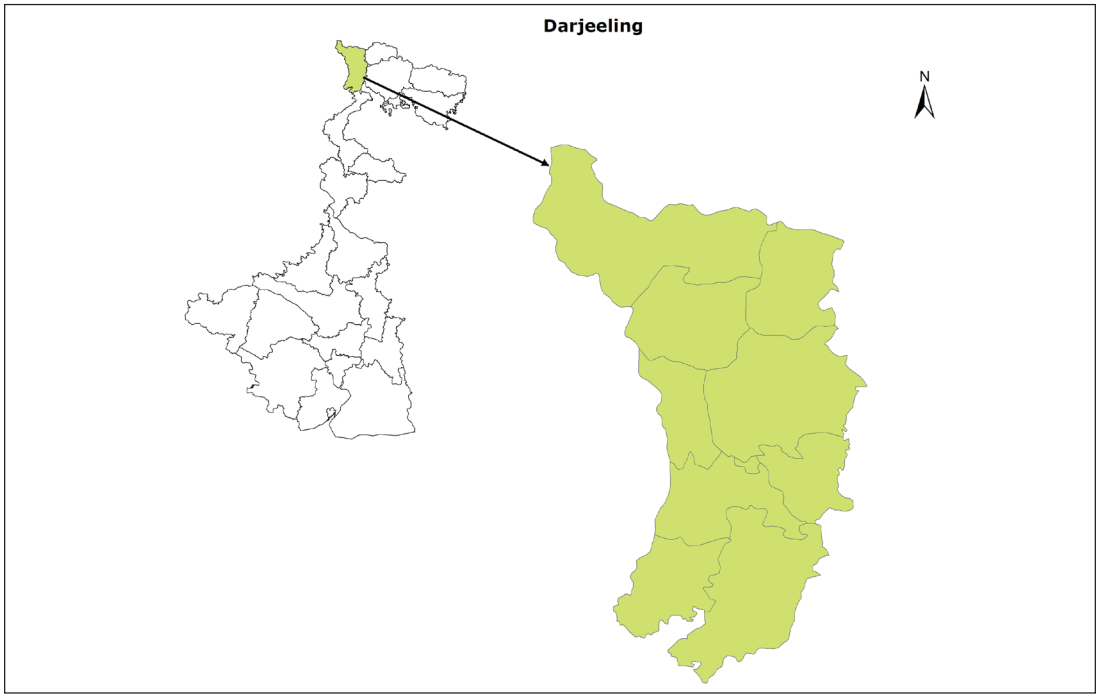


Fig. 7 : Major soil classification

humid (moist) to humid (inclusion of per humid) eco subregion of the agro-eco subregion 15.1 (ICAR). It is classified under Lower Gangetic Plain Region (III) of agro-climatic zoning of planning commission and under coastal saline zone (WB-6) and new alluvial zone (WB-4) of agro-climatic zoning of NARP. The geographical area of the district is 3.88 lakh ha, out of which cultivable area is 2.61 lakh ha (Fig. 5). Gross cropped area of the district is 5.20 lakh ha, out of which 2.59 lakh ha is net sown area and 2.61 lakh ha area is double cropped area. The area under the rainfed condition is 0.58 lakh ha and under irrigation is 6.62 lakh ha. The major source of irrigation in the district are canals, borewells, tanks and other sources. The major crops grown in the district are rice, jute, oilseeds, pulses, wheat, potato and fruit crops like mango, banana, papaya, jackfruit, guava and vegetable crops like brinjal, cabbage, cauliflower and tomato. Indigenous cattle, crossbred cattle, indigenous buffaloes, goat and sheep farming is widely practiced. The average annual rainfall of the district is 1424 mm and out of which 69 % is received in *kharif* (Fig. 6). The predominant soils in the district are loamy, clay loamy and clayey soils (Fig. 7).

1.3.3 Darjeeling

Darjeeling district is located between 27° 09' N latitude to 88° 45' E longitude with an elevation of 2134 m above MSL. The district is categorized into Eastern Himalayas, warm per humid eco sub region of the agro-eco subregion 16.2 (ICAR). It is classified under Eastern Himalayan Region (II) of agro-climatic zoning of planning commission and Hill Zone (WB-1) of agro-climatic zoning



of NARP. The geographical area of the district is 3.25 lakh ha out of which cultivable area is 1.60 lakh ha (Fig. 8). Gross cropped area of the district is 1.75 lakh ha, out of which 1.43 lakh ha is net sown area and 0.32 lakh ha area is double cropped area. The area under the rainfed condition is 0.46 lakh ha and irrigated area is 0.12 lakh ha. The major source of irrigation in the district are

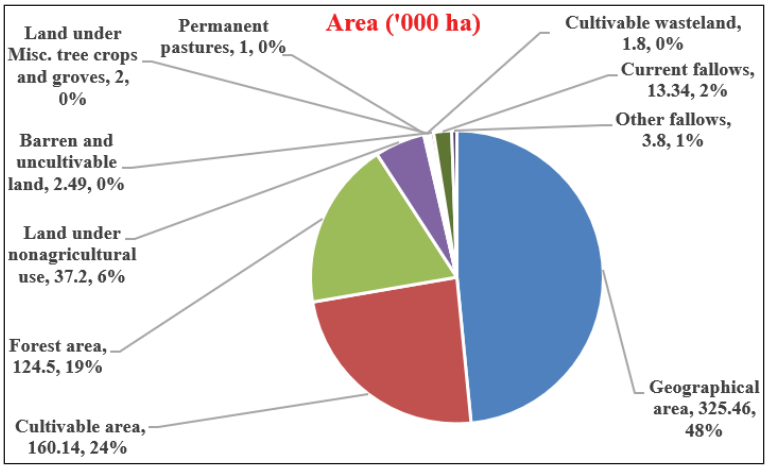


Fig. 8 : Land use pattern of Darjeeling

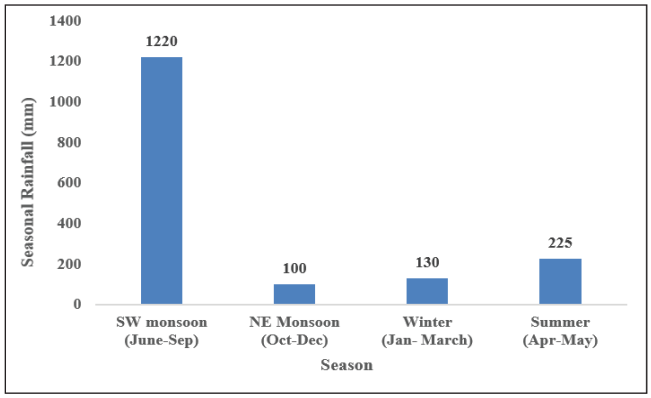


Fig. 9 : Season-wise rainfall (mm)

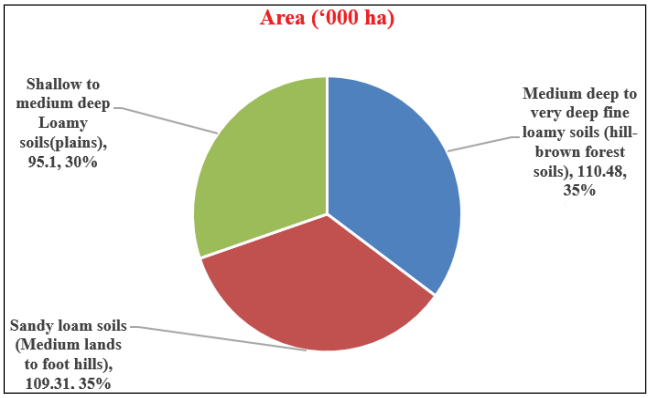
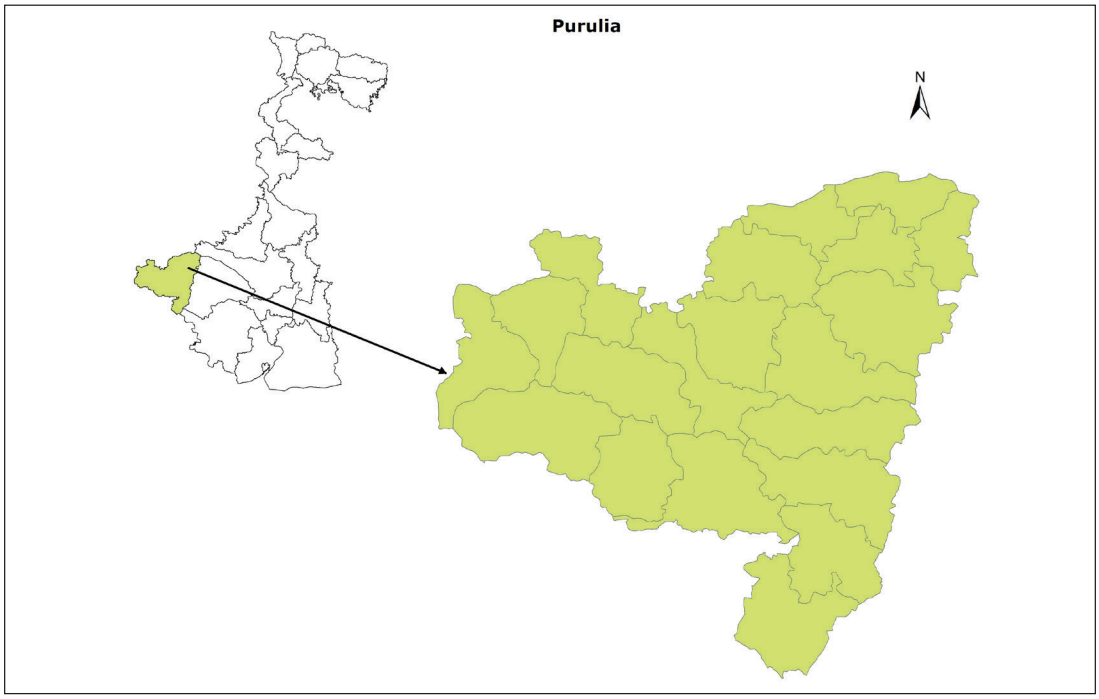


Fig. 10 : Major soil classification

open wells, borewells, lift irrigation, micro irrigation and other sources. Major crops grown in the district are rice, maize, wheat and fruit crops like pineapple, mandarin, citrus, mango, litchi and vegetable crops like brinjal, cabbage, cauliflower and radish. Indigenous cattle, crossbred cattle, indigenous buffaloes, goat and sheep farming is widely practiced. The average annual rainfall of the district is 1675 mm, out of which 72 % is received during *kharif* (Fig. 9). The predominant soils in the district are medium deep to very deep fine loamy soils (hill-brown forest soils), sandy loam soils (medium lands to foot hills) and shallow to medium deep loamy soils (plains) (Fig. 10).

1.3.4 Purulia

Purulia district is located between 23° 02' N latitude to 86° 22' E longitude with an elevation of 228 m above MSL. The district is categorized into Eastern Plateau (Chhotanagpur) and Eastern Ghats, hot sub humid eco-subregion of agro-ecological subregion 12.3 (ICAR). It is classified under Lower Gangetic Plain Region (III) of agro-climatic zoning of planning commission and Red and Laterite soil Zones (WB-5) of agro-climatic zoning of NARP. The geographical area of the district is 6.25 lakh ha, out of which 4.28 lakh ha is cultivable area (Fig. 11) Gross cropped area of the district is 3.74 lakh ha, out of which 3.17 lakh ha is net sown area and 0.57 lakh ha area is double cropped area. The rainfed and irrigated area is 1.42 lakh ha and 3.02 lakh ha, respectively. The major source of irrigation in the district are canals, tanks, lift irrigation, micro irrigation and other sources. Major crops grown in the district are rice, maize, pulses, oilseeds, potato and fruit crops like mango, papaya, banana, pineapple, guava and vegetable crops like brinjal, tomato, cabbage, cauliflower and lady's finger. Indigenous cattle, crossbred cattle, indigenous buffaloes, goat and sheep farming is widely practiced. The average annual rainfall of the district is 1328 mm, out of which 77% of the rainfall is received during *kharif* season (Fig. 12). The predominant soils in



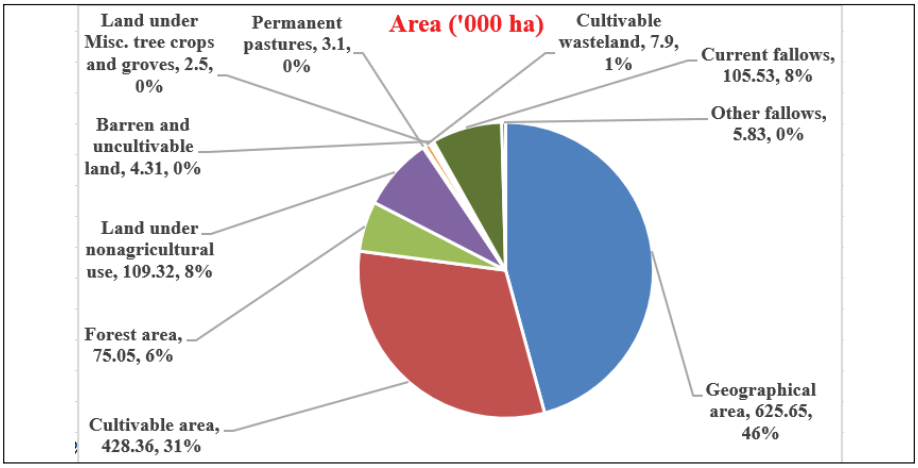


Fig. 11 : Land use pattern of Darjeeling

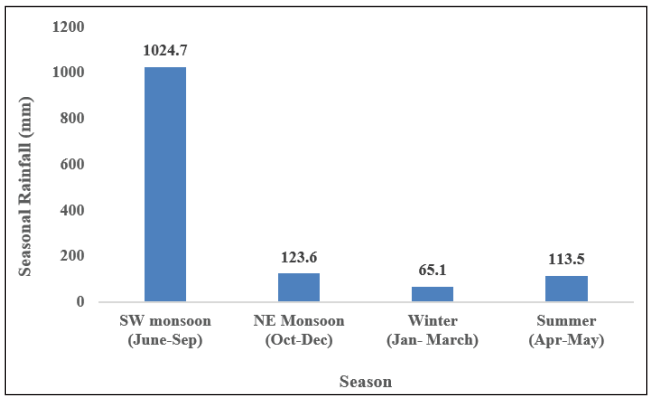


Fig. 12 : Season wise rainfall (mm)

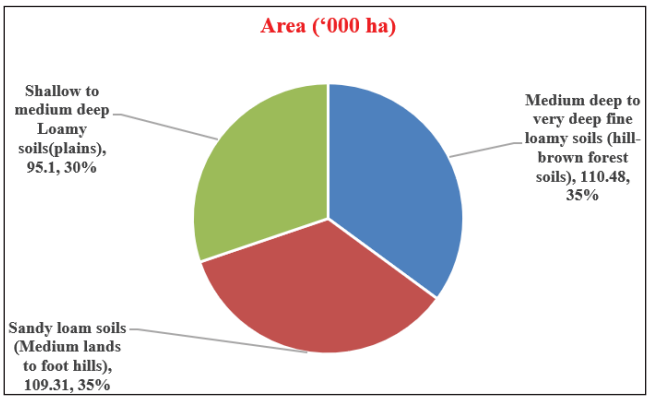
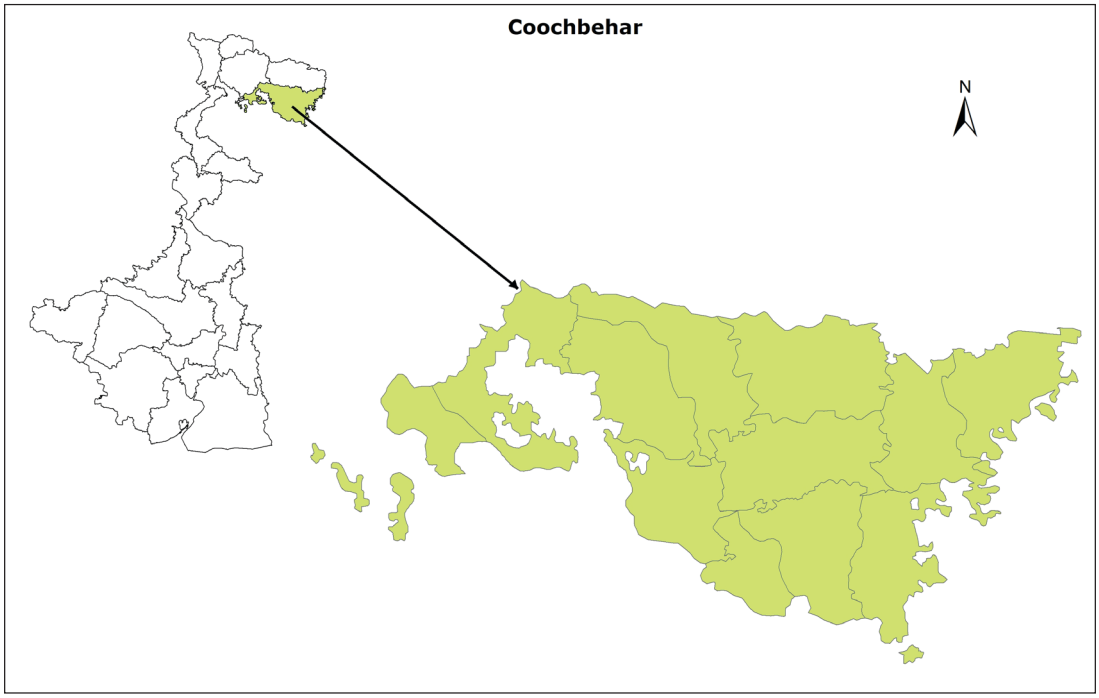


Fig. 13 : Major soil classification

the district are shallow to moderately deep, coarse loamy to fine loamy soils (hillocks, gravelly situation), moderately deep to deep, coarse loamy to fine loamy red soils and shallow to moderately deep loamy soils (Fig. 13).

1.3.5 Cooch Behar

Cooch Behar district is located between 26° 03' N latitude to 89° 18' E longitude with an elevation of 37 m above MSL. The district is categorized into Assam and Bengal Plain, hot sub humid to humid (inclusion of per humid) eco-subregion of agro-ecological subregion 15.3 (ICAR). The district is classified under Lower Gangetic Plain Region (III) of agro-climatic zoning of planning commission and New Alluvial Zone (WB-4) of agro-climatic zoning of NARP. The geographical area of the district is 3.38 lakh ha out of which cultivable area is 2.53 lakh ha (Fig. 14) Gross cropped area of the district is 4.69 lakh ha, out of which 2.48 lakh ha is net sown area and 2.21 lakh ha area is double cropped area. The area under rainfed condition is 1.68 lakh ha and under irrigation is 3.8 lakh ha. The major source of irrigation in the district are canals, tanks, borewells, lift irrigation and other sources. Major crops grown in the district are rice, jute, mustard, tobacco, potato and fruit crops like banana, jackfruit, mango, litchi, guava and vegetable crops like chilli, brinjal, cabbage, cauliflower and radish. Indigenous cattle, crossbred cattle, indigenous buffaloes,



goat and sheep farming is widely practiced. The average annual rainfall of the district is 2914 mm, out of which 65 % of the rainfall is received in *kharif* season (Fig. 15). The predominant soils in the district are sandy to coarse loamy soils and deep to very deep fine loamy soils (Fig. 16).

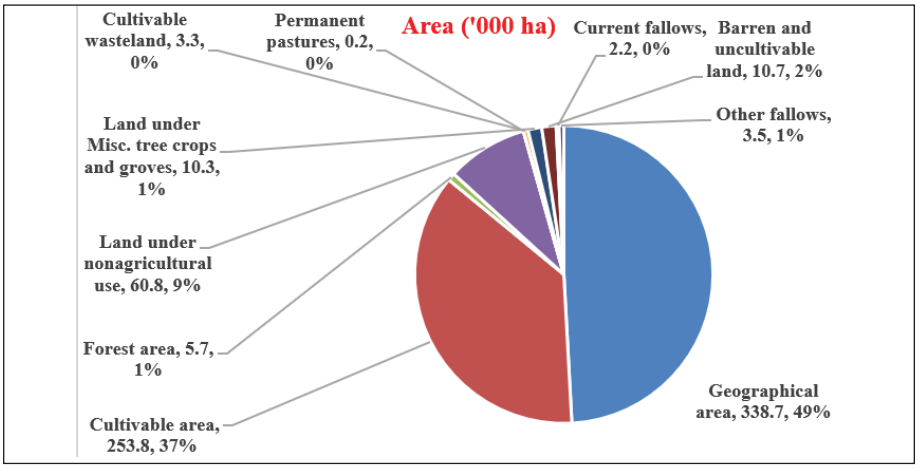


Fig. 14 : Land use pattern of Cooch Behar

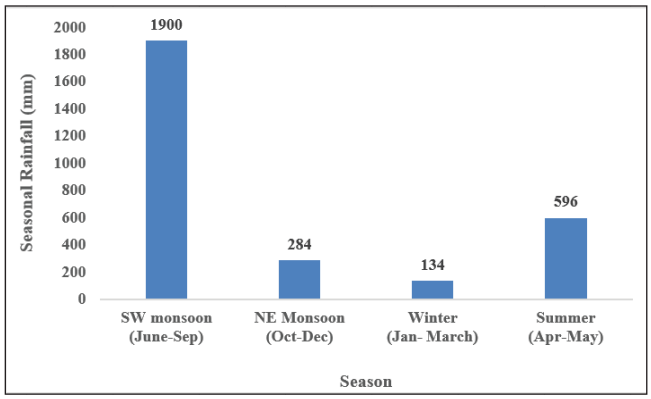


Fig. 15 : Season wise rainfall (mm)

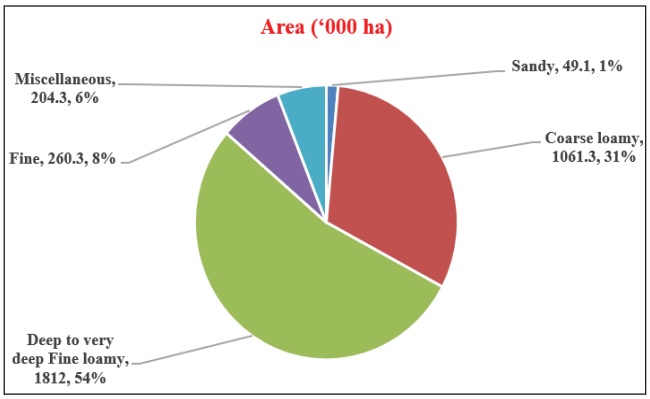
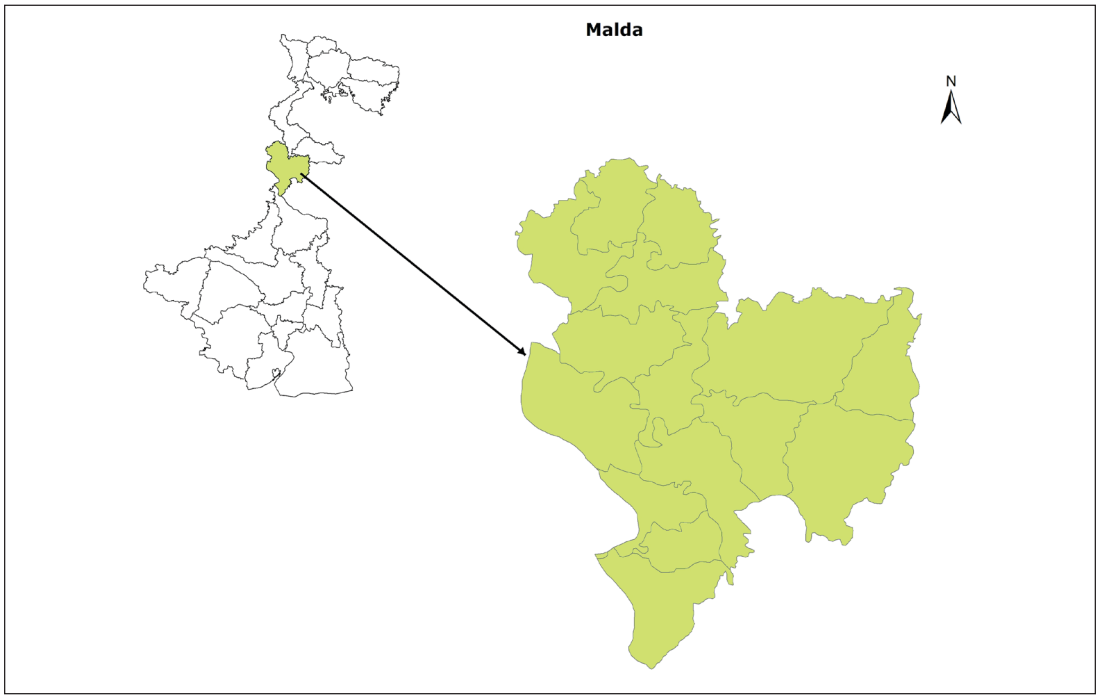


Fig. 16 : Major soil classification

1.3.6 Malda

Malda district is located between 25° 03' N latitude to 88° 27' E longitude with an elevation of 25 m above MSL. The district is categorized into Bengal and Assam plains, hot sub humid (moist) to humid (inclusion of per humid) eco-sub region of agro-ecological sub region 15.1 (ICAR). The district is classified under Lower Gangetic Plain Region (III) of agro-climatic zoning of planning



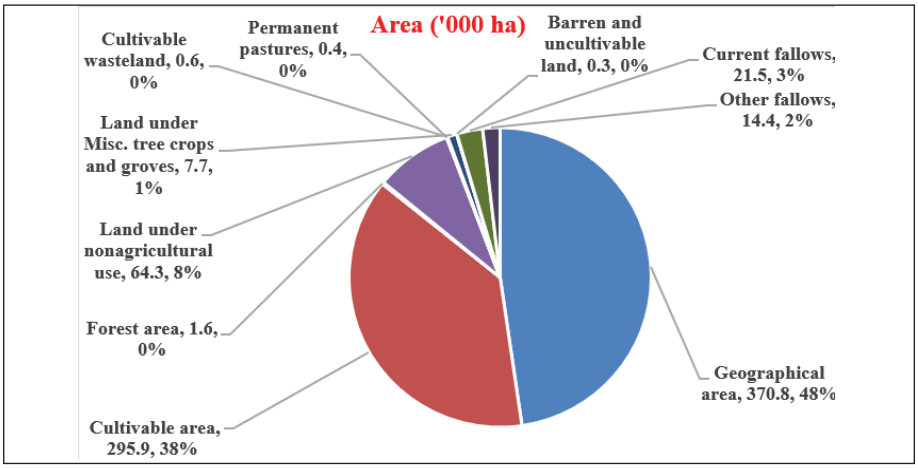


Fig. 17 : Land use pattern of Malda

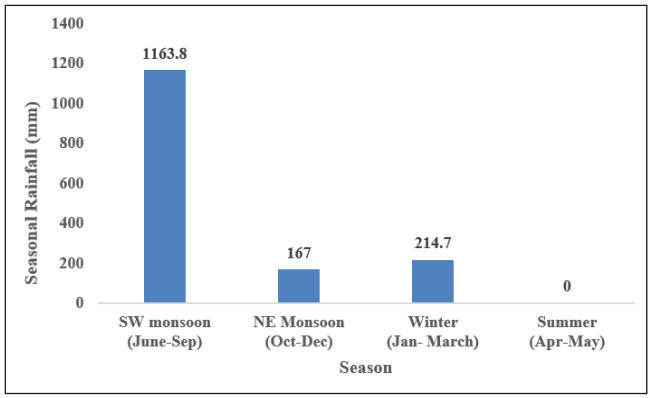


Fig. 18 : Season wise rainfall (mm)

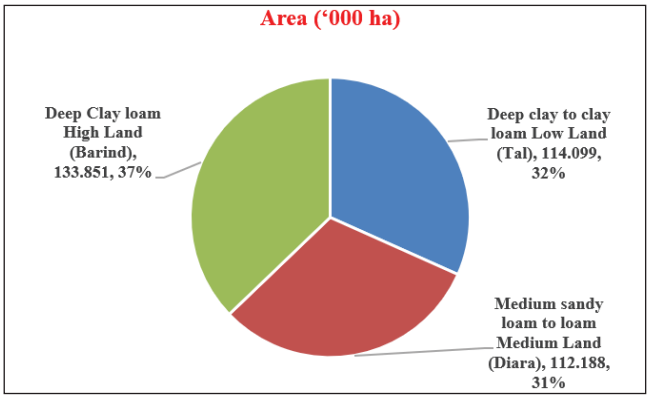
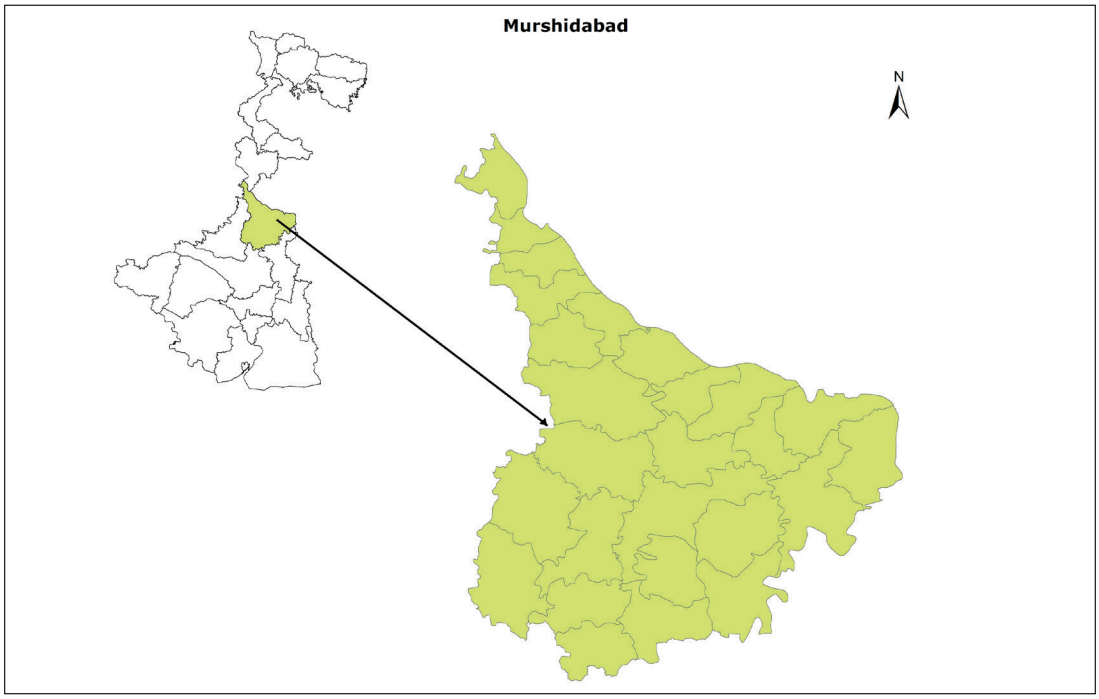


Fig. 19 : Major soil classification

commission and New Alluvial Zone (WB-4) & Old Alluvial Zone (WB-3) of agro-climatic zoning of NARP. The geographical area of the district is 3.70 lakh ha, out of which cultivable area is 2.95 lakh ha (Fig. 17). Gross cropped area of the district is 4.74 lakh ha, out of which 2.60 lakh ha is net sown area and 2.14 lakh ha area is double cropped area. The area under rainfed and irrigated condition is 1.34 lakh ha and 5.84 lakh ha, respectively. The major source of irrigation in the district are tanks/surface flow irrigation, deep tube wells, bore wells, lift irrigation and other sources. Major crops grown in the district are rice, mustard, wheat, jute, black gram, sugarcane, maize and fruit crops like mango, litchi, banana, papaya, guava, jack fruit and vegetable crops like potato, cabbage, cauliflower, tomato and peas. Indigenous cattle, crossbred cattle, indigenous buffaloes, goat and sheep farming is widely practiced. The average annual rainfall of the district is 1545 mm, out of which 75% of the rainfall is received in *kharif* season (Fig. 18). The predominant soils in the district are deep clay to clay loam low lands (Tal), medium sandy loam to loam medium lands (Diara) and deep clay loam high lands (Barind) (Fig. 19).

1.3.7 Murshidabad

Murshidabad district is located between 24° 03'' N latitude to 88° 16'' E longitude with an elevation of 19 m above MSL. The district is categorized into Assam and Bengal Plain, hot sub humid to humid (inclusion of per humid) eco-subregion of agro-ecological subregion 15.1 (ICAR). The district is classified under Lower Gangetic Plain Region (III) of agro-climatic zoning of planning commission and New Alluvial Zone (WB-4) & Old Alluvial Zone (WB-3) of agro-climatic zoning of NARP. The geographical area of the district is 5.32 lakh ha, out of which cultivable area is 3.99 lakh ha (Fig. 20). Gross cropped area of the district is 9.76 lakh ha, out of which 3.98 lakh ha is net sown area and 5.77 lakh ha area is double cropped area. The area under rainfed conditions is



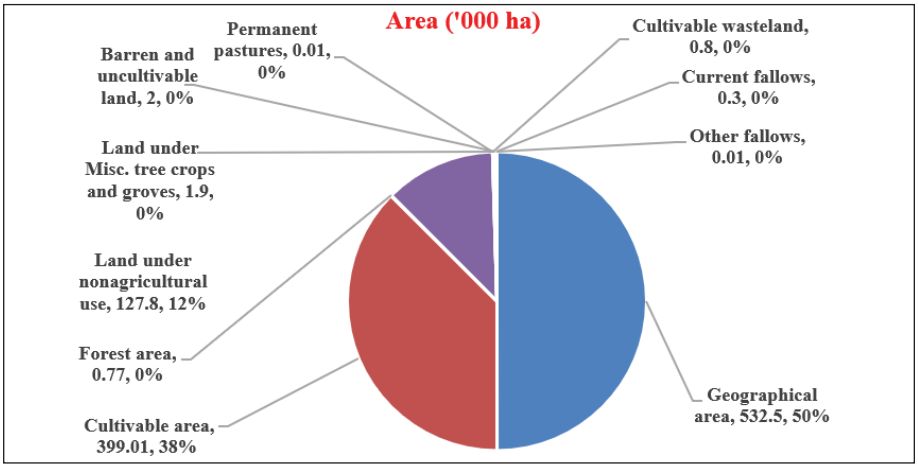


Fig. 20 : Land use pattern of Murshidabad

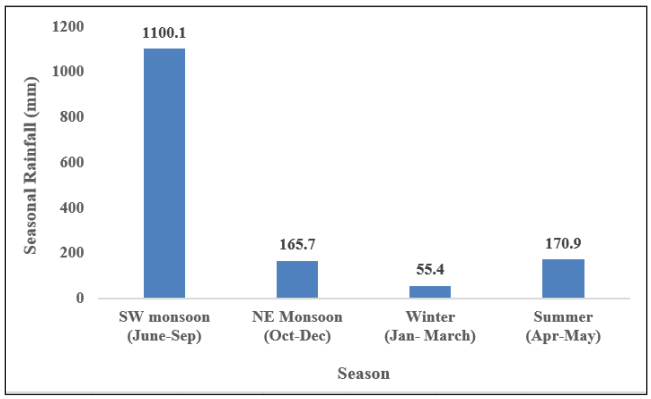


Fig. 21 : Season wise rainfall (mm)

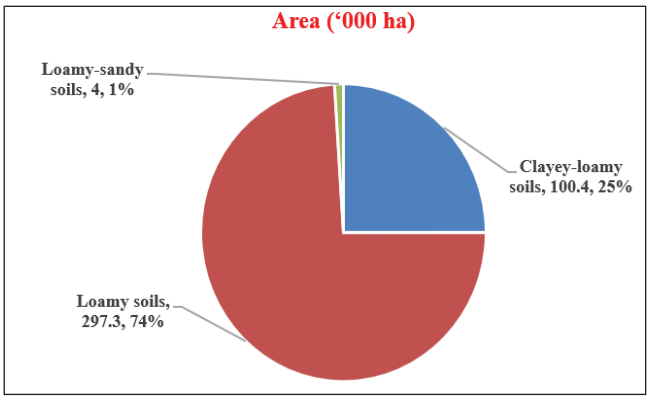


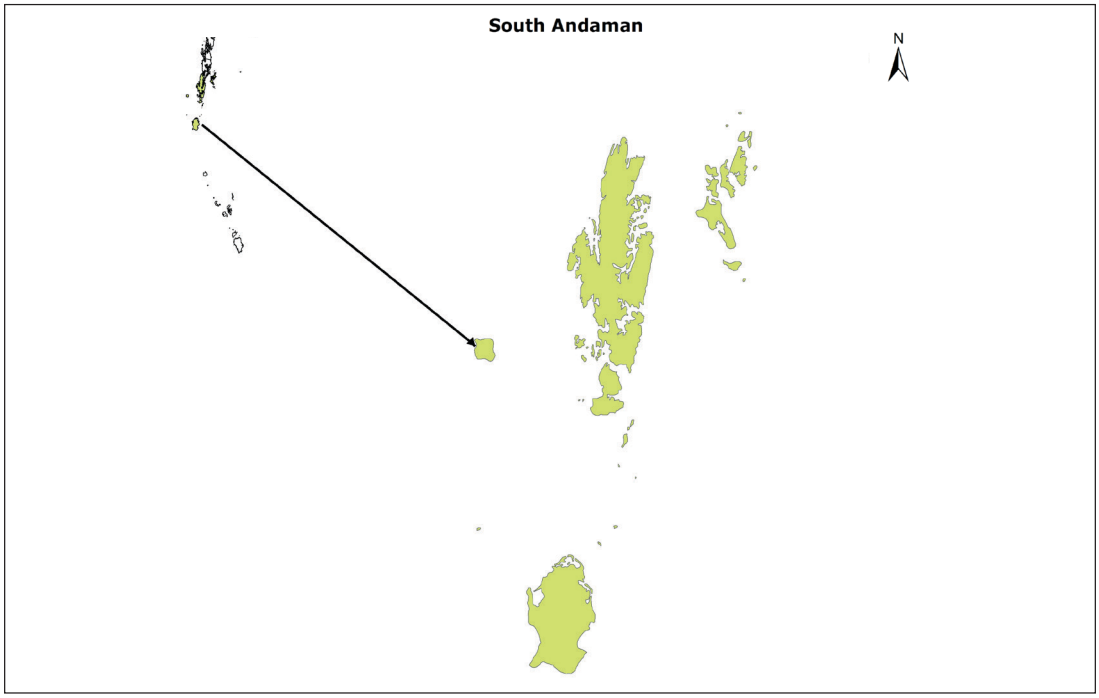
Fig. 22 : Major soil classification

4.08 lakh ha and under irrigation is 7.71 lakh ha, respectively. The major source of irrigation in the district are canals, tanks, lift irrigation and other sources. Major crops grown in the district are rice, wheat, pulses, oilseeds, jute, potato and fruit crops like banana, jackfruit, mango, guava, litchi and vegetable crops like brinjal, cabbage, cauliflower, tomato and lady's finger. Indigenous cattle, crossbred cattle, indigenous buffaloes, graded buffaloes, goat and sheep farming is widely practiced. The average annual rainfall of the district is 1492 mm, out of which 73 % of the rainfall is received in *kharif* season (Fig. 21). The predominant soils in the district are clay loam, loamy and loamy sand soils (Fig. 22).

1.3.8 Port Blair (South Andaman district)

Port Blair (South Andaman district) is located at 11.40° N latitude and 92.45° E longitude, with an elevation of 79 m above mean sea level (MSL). The district falls under Agro-Ecological Sub Region 20.1 (humid to perhumid island ecosystem) (ICAR classification) and is classified under the Islands Region-XV of the Planning Commission's agro-climatic zoning. It is not listed under any NARP agro-climatic zone due to its island-specific agro-ecosystem.

The geographical area of Port Blair (South Andaman district) is 3.11 lakh ha, out of which the cultivable area is 0.69 lakh ha and forest area is 2.67 lakh ha. The gross cropped area of the district is 7,141 ha, with a net sown area of 6,894 ha and an area sown more than once of 247 ha, resulting



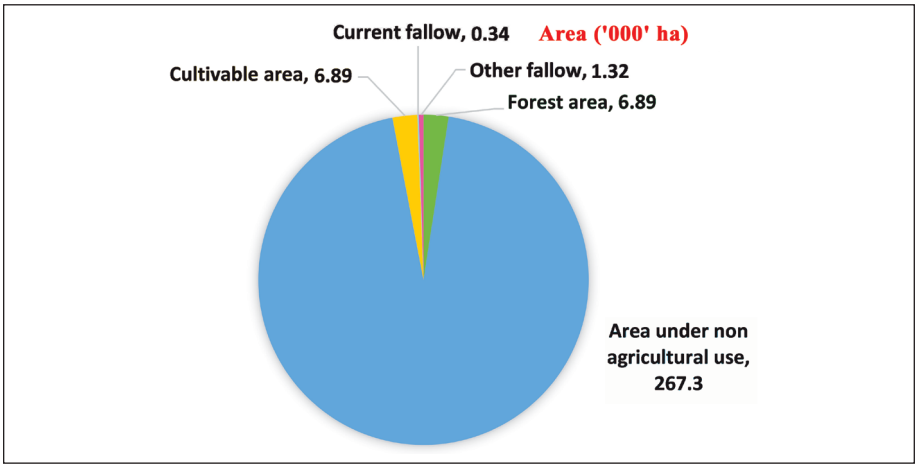


Fig. 23 : Land use pattern of South Andaman

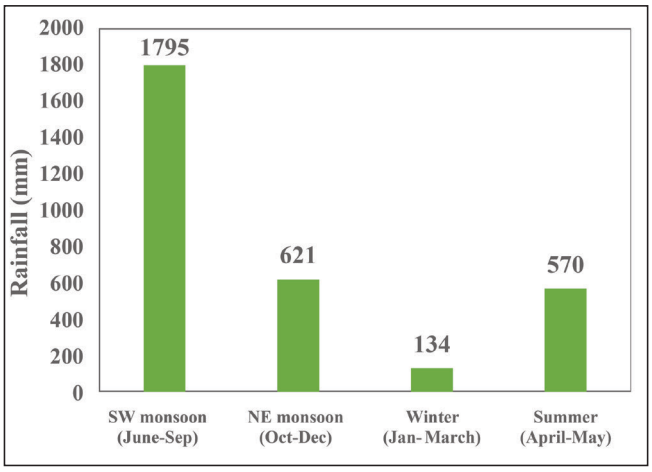


Fig. 24 Seasonwise rainfall (mm)

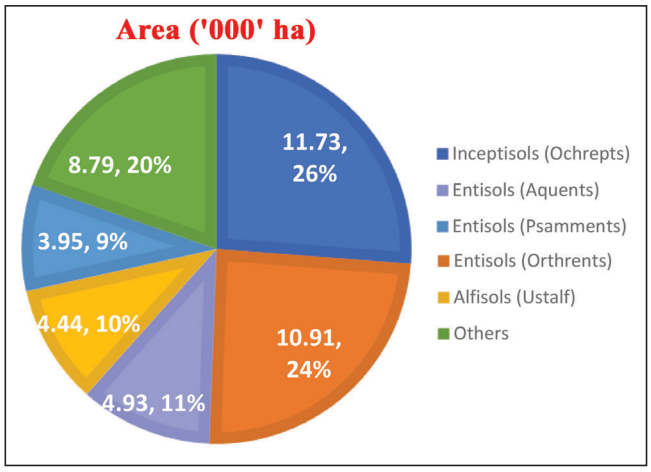


Fig. 25 Major soil classification

in a cropping intensity of 104%. The area under rainfed conditions is predominant, as only 247 ha is irrigated (mainly using open wells and ponds), while the remaining cultivated area depends on rainfall. The major sources of irrigation include ponds (718 ponds reported) and open wells (396 units). The major crops grown in the district include rice (main *kharif* crop with ~317 ha area), pulses (green gram, black gram), maize, sugarcane, and tuber crops (sweet potato, tapioca). Plantation crops are dominant, with coconut (3,560 ha), arecanut (2,235 ha), rubber (265 ha), oil palm (1,593 ha), and cashew nut (29.5 ha). Horticultural crops include fruits such as banana, mango, papaya, sapota, pineapple and vegetables like chillies, sweet potato, tapioca, brinjal, okra, and cabbage. The livestock sector includes indigenous and crossbred cattle (total 17,927), buffaloes (985), goats (27,564), pigs (3,075) and a significant poultry population of over 665,000 birds. The average annual rainfall of Port Blair (South Andaman district) is 3,120.6 mm, with 58% of the rainfall received during the southwest monsoon (June–September) and additional rainfall during the northeast monsoon (October–December) and summer months (April–May). The predominant soils in the district include Inceptisols (26.2%), Entisols (44% combined as Orthents, Aquents, Psamments, Fluvents), and Alfisols (9.9%), which are generally acidic, sandy loam to clay loam in texture.

2. Promising Climate Resilient Technologies

2.1 Promising Natural Resource Management Technologies

Rain water harvesting for life saving irrigation to *rabi* crops

Climate vulnerability: High rainfall

Background: A large area of the NICRA village, Khagribari of Cooch Behar district is fallow during *rabi* season, as only 32% of the cultivated area is irrigated with bore well by lifting ground water. Though a number of small and large sized water bodies exist, most of them are seasonal and cannot be used as source of irrigation during critical stages of *rabi* crops because 1) the water holding capacity of the soil is very poor due to coarse texture 2) average depth of ponds ranges from 5.5 - 7.0ft from the ground level. On the other hand, the village experiences average annual rainfall of about 3000 mm, received mostly during April-August.

Details of technology: Considering the huge scope of harvesting the rain water, Cooch Behar KVK renovated a number of existing water bodies to utilize the harvested rain water for life saving irrigation to *rabi* crops emphasizing *rabi* vegetables and to convert the seasonal water bodies into perennial ones, thus suitable for year-round pisciculture (Table 1).

A total of 15 ponds having an average depth of 5-7 ft. were selected for renovation at different corners of the village which remains dry from December onwards. Usually ponds of 9 ft depth or more can retain the water throughout the year. Hence the depth of selected ponds is increased from 5.5 - 7.0 ft. up to 10.5 - 11 ft. (from ground level), so that water stored in the water bodies can be used for life saving irrigation of *rabi* crops with special emphasis on vegetables during mid-December to mid-March.

Table 1: Effect of pond renovation on increase in water reserve

Sl. No.	Farmer's name	Pond volume (cu. m)		Increase (cu. m)	Water used for irrigation (cu. m)
		Before	After		
1.	Shymal Sarkar	1,307	2,590	1,283	702
2.	Utpal Dey	1,409	2,590	1,181	670
3.	Nandalal Sarkar	1,292	2,380	1,088	606
4.	Jantu Ram Singh	1,345	2,590	1,245	698
5.	Prasenjit Talukdar	1,278	2,380	1,102	624
6.	Khageswar Barman	1,265	2,380	1,115	594
7.	Akbar Ali	1,236	2,170	934	486
8.	Amal Sarkar	1,222	2,170	948	526
9.	Bikram Sarkar	1,314	2,170	856	482
10.	Dulal Talukdar	1,198	1,960	762	418
11.	Ansar Ali	1,225	1,960	735	385
12.	Khalilur Rahaman	1,161	1,960	799	442
13.	Badrul Alam	1,119	1,750	631	359
14.	Tofajjal Hossain	1,195	1,750	555	296
15.	Janab Ali	1,166	1,750	584	332
	Total	18,733	32,550	13,817	7,620

Performance and impact of technology: Total area under cultivation during *boro* season has been increased by 25.9 ha and thereby increasing the cropping intensity from 183% to 188%.

The productivity of potato has increased by 5% (from 24.3 to 25.5 t ha^{-1}), while that of wheat has increased by 13% (from 27.56 to 31.24 t ha^{-1}). The net monitory returns (NMR) for potato and wheat have also increased by 4% and 32%, respectively (Table 2). The yield increase recorded in potato may be due to supplemental and timely irrigation, where as in wheat yield increase was due to higher number of irrigations.

Table 2: Effect of pond renovation on area coverage under irrigation and net income

Crop	Area (ha)		No. of irrigation		Yield (t ha^{-1})		Net income (₹ ha^{-1})	
	2012-13	2010-11	2012-13	2010-11	2012-13	2010-11	2012-13	2010-11
Potato	24	7.8	1	1	25.5	24.3	73,410	70,400
Wheat	12	2.3	2	1	3.12	2.76	10,371	7,811

Scope for upscaling

Field day was organized with involvement of local panchayat to farmers from nearby locality. Number of pond owner farmers of the NICRA adopted village showed keen interest to renovate existing ponds and approached to KVK as well as gram panchayat for financial help as it was not possible for them to execute the work because of high-cost involvement. Five ponds have also been renovated with financial support from MGNREGA. It can further be scaled up through various developmental programmes of the state and central governments.



Pond renovation work at Khagribari village, Cooch Behar



Depth of water (5.6 ft) at pond (not renovated)



Depth of water increased to 11.6 ft at renovated pond

Jalkund: A low-cost climate-resilient solution for supplemental irrigation in rainfed areas

Climate vulnerability: Moisture stress

Background: The district receives high rainfall but lack of suitable rainwater harvesting and management lead to severe water scarcity, particularly during the post-monsoon period. Rainwater storage and efficient use of it holds is the key to sustainable livelihood.

Details of technology: Jalkund are small water harvesting structures that act as a supplementary source of irrigation water throughout the year. This is a water harvesting and saving technology. These structures are primarily meant for rainwater harvesting. They can be very helpful in facilitating irrigation throughout the year, especially during the dry spells particularly for small and marginal farmers.

Performance and impact of technology: Jalkund technology performs well basically in the regions of heavy rainfall during monsoon followed by dry spell during *rabi* season. As the farmers of NICRA adopted village Paiyong are extensively engaged on vegetable cultivation, jalkund is indeed crucial for farmers as it supports their cultural activities and helps in addressing water scarcity challenge. Jalkund of 18 ft ×10 ft × 5 ft with water holding capacity of more than 18000 liter was constructed at NICRA adopted village Paiyong, during the year 2022-23 under NICRA project by Krishi Vigyan Kendra, Kalimpong in Darjeeling district. Jalkund was constructed to cope up with the changing climate and the erratic rainfall. 10 farm households were benefitted from this jalkund. The Jalkund helped to increase the cropping intensity by 15-18% (Table 3). The tomato, dalley chilli, cole crops, beans etc.

The jalkund in paiyong helped the farmers by addressing the water scarcity of crops by providing supplemental irrigation. Since the farmers were convinced with the benefits of jalkund and realized that this is the practical solution for water scarcity especially during the dry season. Hence farmers initiated the construction of jalkund for rain water harvesting on their own.

Table 3: Impact of jalkund technology in NICRA village Paiyong, Darjeeling

Intervention	No. of jalkunds constructed	Storage capacity	Crops/activities undertaken	No. of farmers benefitted	Increase in cropping intensity (%)
Jalkund technology	1	18,370 litres	Tomato, Dalley Chilli, Cole crops, Beans etc	10	15-18

Scope for upscaling: The technology of jalkund construction can be extended to the entire district through convergence with state departmental activities, central programmes and ATMA.





Jalkund construction at NICRA village Paiyong.

Mulching: An effective technology for resource utilization in okra production

Climate vulnerability: Flood & Cyclone

Background: Vegetable crops like bhindi, chilli etc are predominant crops in the district of Murshidabad apart from jute, paddy, pulse and oilseeds. In the operational area, vegetables are grown traditionally but the productivity is less than the national average and quality of the produce is not at the desired level. As per farmers' observations, the major problems for cultivation of vegetables were heavy weed infestation, poor soil moisture, irregular erratic rainfall with low irrigation potential. Hence, there is a great scope for the resource conservation practices such as poly mulching to grow and make vegetables available in the market.

Details of technology: Poly-mulching is practice of covering the soil/ground and provide favourable conditions for plant growth, development and efficient crop production. Natural mulches such as leaf, straw, dead leaves and compost can be used. Plastic mulches also can be used. The plastic mulches are completely impermeable to water; it therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface also and suppresses the weed growth. It also helps to conserve moisture level in soil. Mulching is mainly implemented in rainfed area for moisture conservation. The mulch film of 15micron thick film is required due to advent of film extrusion technology. The rate of plastic mulch film is ₹ 2,700 / 400 meter.

Mulching reduces the weed infestation thus reducing the cost of weeding. Mulching can be done by using a variety of locally available materials like black plastic, white plastic, rice straw, saw dust etc. The black plastic sheet of 25micron was used as mulch for demonstration at Sujapur, Beldanga-1 block, Murshidabad. The perforations were made on the plastic sheet as per the intra row spacing (30 cm). The row-to-row distance was 50 cm and plant to plant distance was 30 cm. The sowing was done during mid of February, 2023. The weather during this period was dry and hot. The crop was cultivated as per the recommended package of practices.

Performance and impact of mulch: With the adoption of mulching technology, it was noted that seed germination was better compared to no mulch plots (farmers' practice). In addition to germination, plant height and plant vigor were improved in mulch plants, the plastic mulch also favored the micro-climate for plant growth.

Table 4: Effect of plastic mulch on okra yield and economics

Intervention	Numbers of fruits/plant	Average fruit weight (g)	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	BC ratio
Black polythene mulch	34.66	14.33	26.33	80,350	2,63,300	3.28
Farmers' practice	27.33	11.66	20.67	94,650	2,06,700	2.18

The number of fruits per plant, number of pickings were more in mulch plots, which ultimately reflected in crop yields. The productivity of mulch plots was increased to the tune of 27.38% compared to non-mulch plots. The fruit weight and appearance of fruit were improved, which might be due to low pest infestation, conservation of soil moisture and restricting leaching loss of nutrient by mulching. The ambient temperature provided by the plastic mulch might have also favored the plant growth. Furthermore, the mulching reduced the weed growth. So, mulching can be an important practical aid for the soil moisture conservation which eventually reduces the number of irrigations and lower cost of cultivation. Hence mulching helped in increasing the productivity and net monetary returns by 27 and 63%, respectively (Table 4).

Scope for upscaling: It may be multiplicated in farmers' fields through Front Line Demonstrations of KVK along with different demonstration programmes through centrally sponsored schemes like ATMA by departments of agriculture and horticulture of Government of West Bengal.



Demonstration plots of mulching in okra field under NICRA village of Murshidabad

Poly mulching in Dalley Chilli

Climate vulnerability: Flood & Cyclone

Background: Chilli is heavy feeder of manure and long duration crop. It requires balanced dose of fertilizer along with proper moisture level for better yield and quality of produce. The crop of chilli is indeterminate in nature and require nutrition and irrigation up to fruit ripening and maturity. Hence maintaining optimum soil moisture is crucial for higher crop yield.

Details of technology: Poly-mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop production. When compared to other mulches, plastic mulches are completely impermeable to water and prevent direct evaporation of moisture from the soil, soil erosion over the surface and also suppresses weed growth. Mulching is mainly implemented in rainfed area for moisture conservation. Poly-mulching was demonstrated in dally chilli cultivation NICRA villages of Kalimpong district.

Performance and impact of technology: Demonstrations on Dalley Chilli cultivation with plastic mulch was conducted in 0.80 ha area involving 10 farmers in NICRA village of Kalimpong district, West Bengal during 2021-22. The performance of dalley chilli was significant as compared to traditional cultivation. The poly mulching resulted in significant reduction of weed growth. Plastic mulching reduced the cost of cultivation as compared to conventional method due to saving in irrigation and weed management. The technology has helped the farmers to achieve a yield improvement of 22.79 % and BC ratio of 3.28 respectively (Table 5).

Table 5: Impact of Poly-mulching on Dalley Chilli in NICRA village of Kalimpong district

Intervention	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Dalley chilli cultivation in Poly mulching	1.51	55,000	1,80,750	3.28
Farmers Practice	1.16	30,000	86,200	2.87

Scope for upscaling: The technology can be scaled up as farmers were very much encouraged by the significant impact in yield performance which is also cost effective.



Cultivation of Dalley chilli using Poly-mulching technology in NICRA village, Kalimpong district

Plastic mulch in bitter gourd production in trellis system during *kharif* season

Climate vulnerability: High rainfall

Background: One of the most popular cucurbitaceous vegetables grown in the Cooch Behar district of West Bengal is bitter gourd. In North Bengal, bitter gourd seeds are typically sown by farmers between last week of March to the third week of April. Heavy rains during the crop's growing season, particularly in May and June, have an impact on the yield. This prolonged period of severe rain decreases the yield of this crop by causing soil erosion, fertilizer and nutrient leaching, pest and weed infestation. As a result, growers occasionally may not even recover their production costs.

Details of technology: In order to solve this issue, KVK Cooch Behar demonstrated the mulching technique to the farmers. The seedlings were prepared in nursery. In the main field, raised beds of 1 meter were prepared. After the bed is prepared the manures and the fertilizers were mixed with soil, and later the bed is covered with transparent plastic sheet (30-micron thickness one side black and another side silver colour). Thirty days old seedlings of bitter gourd (var. Mahyco MBTH 101) were transplanted in the raised bed. About 2 seedlings were transplanted on each bed. The weed growth was less in mulch plots All the plots were uniformly irrigated as and when required based on crop growth. Recommended plant protection measures were adopted as and when needed. The bitter gourd fruits were harvested in 4-5 pickings.

Performance and impact of technology: The plastic mulched crop of bitter gourd matured 15 days earlier over the non-mulched crop. Harvesting started 45 days after planting. The vine length, number of leaves per plant, number of fruits per plant, fruit length, fruit weight and fruit yields were better than non-mulched.

The cost of cultivation was reduced since number of weedings and irrigations were reduced. The yield of bitter gourd was 55.0 % higher over no mulch. The cost-benefit ratio of bitter gourd production under plastic mulching was 1:2.74 with a net profit of ₹ 13,4075 per hectare, whereas the cost-benefit ratio under non-mulched crop was 1:1.46 along with a net profit of only ₹ 39,500 per hectare. Therefore, this technology is highly suitable and economical for bitter gourd for taking high yield and high profit of the produce.

Scope for upscaling: The technology can be spread to the entire districts through convergence with state and central department, ATMA and NGOs.







Use of plastic mulch in bitter gourd production in trellis system at Cooch Behar

Organic mulch in vegetables

Climate vulnerability: Moisture stress

Background: The main goal in production systems is to conserve natural resources and increase water use efficiency and productivity of soils. This can be achieved through mulching either with organic or plastic mulching.

Details of technology: In Malda district, different types of crops like rice, wheat, sugarcane, moong, black gram, lentil and maize are cultivated. Hence, different types of straws are available that can be used as mulching. The organic mulching is advantageous since it adds organic matter to soil when decomposed. Organic mulching can improve the soil health and quality of vegetables. The additional advantage with organic mulching is to use the crop residues and to prevent burning of the crop residues and reduce environmental pollution. Poly or straw mulch conserved higher soil moisture, reduces erosion by protecting the soil surface and also reduces unproductive evaporation from the soil surface, which is a benefit in water stress conditions and plant water status is maintained. Straw mulch prevents the fruits to come in contact with the ground, reduces fruit rot, fruit cracking and blossom end rot. The yield and keeping quality of vegetables has been improved by straw mulch.

Performance and impact of technology: Organic mulching protects the soil from direct exposure to sunlight and reduces evaporation losses. Fields with mulching technology remain free from weeds and maintain availability of soil moisture. Paddy straw is mainly used as a mulching material for vegetables and it reduces irrigation water requirement of the crop by 23%, adds organic matter to the soil, checks the soil temperature and evaporation losses from soil. Application of organic mulch in a stress year enhanced the yield and net monetary returns by 3 and 17% respectively, while the respective increases were by 4 and 20% in a normal year (Table 6).

Table 6: Impact of organic mulching on vegetables at NICRA village of Malda district

Intervention	Year	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Organic mulch technology	Stress year	11.05	54,700	88,300	2.61
Farmers practice (without mulch)		10.7	60,320	75,260	2.24
Organic mulch technology	Normal year	11.3	50,310	97,400	2.93
Farmers practice (without mulch)		10.9	58,200	81,120	2.39

Scope for upscaling: The technology can be scaled up through various programmes being implemented by the state and central governments.





Application of organic mulch (paddy straw) to vegetables (okra) at Malda district

In-situ moisture conservation through organic mulching in vegetable crops

Climate vulnerability: High rainfall

Background: The main goal in production systems is to conserve natural resources and increase water use efficiency and productivity of soils. This can be achieved through mulching either with organic or plastic mulching.

Details of technology: Poly and straw mulch conserve soil moisture, reduce erosion by protecting the soil surface and also reduce unproductive evaporation from the soil surface, which is of benefit in water limited conditions. In order to accomplish these benefits, adoption of conservation practices like mulching were taken up in the NICRA village of Cooch Behar district.

Performance and impact of technology: The utilization of poly and straw mulch in has played a major role in the increases in production of brinjal, tomato, winter cucumber, okra, chilli and pointed gourd among other vegetables and banana. Poly and straw mulch reduced weed emergence by 60% to 80% during the growing season. Mulches are more effective for weed control. Mulch provides many benefits to crop production such as protecting the roots of the plants from heat and cold, making amicable condition for the plant growth by temperature moderation, reducing salinity and weed control and thereby improving the yield and quality of the crop (Table 7).

Table 7: Effect of organic mulching on irrigation in tomato

Technology	Irrigation			Yield (t ha^{-1})	WUE (kg/ha-cm.)
	No.	Water required (ha- cm.)	Cost (₹ ha^{-1})		
Conventional	13	51.53	11,115	26.02	504.95
Demonstration	9	39.77	7,695	26.15	657.53

In tomato, cucumber and banana a saving of 11.76 ha-cm (29.55 %), 8.14 ha-cm (29.50 %) and 9.94 ha-cm of irrigation water (29.8 %), respectively was observed. In addition, a reduction in cost of irrigation by ₹ 3,420.00 ha^{-1}, 30.21% increase in WUE, less weed population, fuel savings 57 lit. diesel ha^{-1} in tomato, reduction in cost of irrigation by ₹ 2,363 and 30.85% increase in WUE, fuel savings 26.25 lit. diesel ha^{-1}, flower drop decrease by 10% and fruiting period increase by 10 days in cucumber and reduction in cost of irrigation by ₹ 3,090.00, 30.72% increase in WUE, less weed population and fuel savings 51.49 lit. diesel ha^{-1} was observed in banana (Table 8&9).

Table 8: Winter cucumber cultivation with poly mulching in BBF

Intervention	Crop	Variety	Date of sowing	Yield (t ha^{-1})	Gross cost (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC Ratio
Conventional	Cucumber	Malini	November	21.1	65,350	1,89,630	1,24,280	2.90
Demonstration	Cucumber	US-447	November	29.8	80,860	2,68,650	1,87,790	3.36

Table 9: Effect of poly-mulching on irrigation in banana

Intervention	Irrigation			Yield (t ha^{-1})	WUE (kg/ha-cm.)
	No.	Water required (ha- cm.)	Cost (₹ ha^{-1})		
Conventional	12	43.28	9,270	46.84	1,083
Demonstration	08	33.34	6,180	47.14	1,415

Scope for upscaling: Farmers will make use of this innovative technique that helps them conserve moisture, avoid weeds and improve soil health tremendously while producing more. This will also go a long way in the world achieving food security sustainably.



In-situ moisture conservation through organic mulching in vegetables at Cooch Behar district

In-situ moisture conservation practices through zero tillage in Wheat

Climate vulnerability: Moisture stress

Background: Traditional conventional tillage causes the soil degradation, depletion of residual soil moisture and nutrient status of soil. Apart from this, due reduction of micro-organisms in soil, the ecosystem of land is changing day by day and weed infestation is increasing resulting in increased cost of cultivation and delayed sowing of wheat after harvesting of rice due to poor soil moisture.

Details of technology: In zero-tillage wheat was sown with minimum disturbance to the soil by planting the seeds immediately after harvesting rice crops. In zero-tillage, wheat can be sown in slits of 2-3 cm wide and 4-7 cm deep the fertilizer also can be applied in one operation at the time of sowing. The machine contains an inverted T-type furrow opener to open the slits. The seed and fertilizer are placed in corresponding boxes and dropped into the slits automatically. A zero-tillage machine can cover 6-7 acres per day. The machine was made available to the farmers through custom hiring center at a rate of ₹ 3000-4000 per hectare.

Performance and impact of technology: In West Bengal, the major area after rice is left fallow. As the sowings of *rabi* crop is delayed due to conventional tillage, since it takes time for land preparation. In view of that, zero tillage cultivation can be practiced and the available soil moisture can be utilized Furthermore, soil degradation can be reduced and soil health can be improved due to addition of crop residue. Zero tillage wheat increased the wheat yield and net returns by 13 and 20% in the stress year, respectively and the respective increase in yield and net returns are 11 and 20% (Table 10). This is due to: (i) timely sowing (ii) increased input-use efficiency (iii) increased organic matter content in the soil.

Table 10: Impact of zero tillage on wheat in NICRA village of Malda district

Intervention	Year	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Sowing in Zero tillage	Stress year	3.54	25,282	30,551	2.20
Farmers Practice		3.13	39,495	25,332	1.64
Sowing in Zero tillage	Normal year	3.85	21,375	34,305	2.60
Farmers Practice		3.47	34,050	28,620	1.84

Scope for upscaling: The technology can be scaled up by making the equipment available through custom hiring centers and by way of various programmes being implemented by the state and central governments.





Wheat sowing with zero-till planter at Malda district

Resource conservation through zero tillage in maize/wheat

Climate vulnerability: High rainfall

Background: In Terai region the main problem is delayed sowing of wheat and maize due to delayed harvesting of *aman* paddy and also land preparation for wheat and maize.

Details of technology: In this region, sowing is mostly done during later half of December, though November 18-25 is considered as the ideal time for getting maximum yields. Generally 5-6 ploughing followed by 2 cross harrowing are generally performed and seeds were broadcasted without application of balanced dose of fertilizers. In this situation zero till sowing is a suitable technology where *rabi* crops were sown directly without land preparation.

Performance and impact of technology: The zero till wheat in Cooch Behar district recorded 19.19 % increase in grain yield; saving of 20 litre of diesel per ha towards land preparation and irrigation; saving of 30 man-days per ha towards entire growing season of wheat and this helped in reduction of cost of production by ₹ 7,500 per ha towards man-days requirement & ₹ 1,200 per ha towards fuel consumption spent for land preparation (Table 11 & 12).

Table 11: Performance of zero tillage wheat

Intervention	Crop	Variety	Date of sowing	Seed yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Conventional tillage	Wheat	Local	Nov.	2.7	32,450	45,900	13,450	1.41
Zero tillage wheat	Wheat	DBW 187	Nov.	3.08	31,125	52,890	21,765	1.69

Table 12: Performance of zero tillage maize

Intervention	Crop	Variety	Date of sowing	Seed yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Conventional tillage	Maize	Local	Nov.	5.32	43,200	82,680	39,480	1.91
Zero tillage maize	Maize	DBW 187	Nov.	6.30	41,850	98,910	57,060	2.36

Scope for upscaling: The technology can be scaled up by making available the equipment through custom hiring centers and convergence with different schemes being implemented by the state and central governments.









Zero-tillage in wheat and maize at Cooch Behar district

Multi crop 4-row planter in Maize

Climate vulnerability: Moisture stress

Background: Mechanization in the agricultural sector is far behind from the other sectors in the state. Farmers are still practicing old practice of cultivation. But, now the new generation is not keen to take agriculture as a source of income generation. For this reason, the labour scarcity is seen everywhere. In addition, the water scarcity of Purulia district is very high especially in summer.

Details of technology: To address this issue, 4-row multi-crop planter was introduced for cultivation of maize. The machine is capable can be used to simultaneously sow the seed and apply the fertilizer. The crop can be sown in line with a spacing of 90 and 25 cm between rows and plants respectively. The seed, fertilizer and labour requirement were reduced compared to normal practice. Hence the cost of cultivation is reduced compared to normal practice.

Performance and impact of technology: The growth of crop sown with 4-row multi-crop planter is very good compared to the normal practice. The yield increase was 118.9% (Table 13). The disease and pest infestation are quite low and the water requirement of the crop is also low compared to normal practice. The cost of cultivation can be reduced due to saving in labour and water. For this reason, farmers are readily adopting this practice.

Table 13: Impact of using 4-row multi-crop planter in maize on yield and economics

Intervention	Yield(t ha^{-1})		Increase (%)	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
	Demo	Normal				
Cultivation of summer maize using 4-row multi-crop planter (P-3535)	3.1	1.4	118.91	55,133	33,098	2.50



Sowing maize crop with 4-row multi-crop planter at Purulia district

Scope for upscaling: This technology has got immense popularity not only among the farmers of NICRA but also in the adjoining six villages and beyond block boundary. It can be further scaled up by various programmes being implemented by the state and central governments. The implement can be made available through custom hiring centers.

Broad Bed cum Trench (BBT) system for higher profitability: A climate-resilient technology in coastal regions

Climate vulnerability: Cyclone & Flood

Background: In the coastal Sundarbans region, most farmers possess small landholdings where excavation of ponds for water storage is often not feasible. These low-lying areas are frequently affected by prolonged submergence and poor drainage, leaving farmers with limited options such as cultivating long-duration traditional paddy. The economic returns from such farming systems are minimal, and opportunities for crop diversification remain negligible. To overcome these challenges, the Broad Bed cum Trench (BBT) system, developed by Ramakrishna Ashram Krishi Vigyan Kendra (RAKVK), Nimpith, was introduced as a climate-resilient land management practice to promote multiple cropping and enhance farm income.

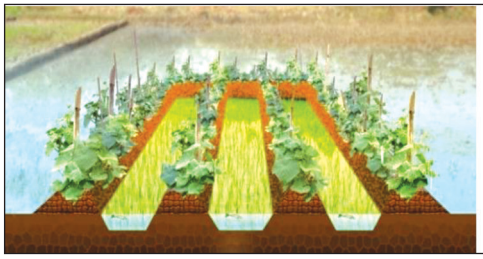
Details of technology: In the broad bed cum Trench system, trenches of 3 feet wide and 3 feet deep are dug at 3 to 6 feet interval across the field. The soil excavated from these trenches is used to raise the intervening land strips (beds) by approximately 3 feet. The rainwater collected in the trenches serves dual purposes-providing irrigation to crops and supporting fish culture for 4–6 months during the monsoon period. The Raised beds are utilized for cultivating vegetables throughout the year. Trenches function as water storage structures and are also used for pisciculture during the rainy season. In winter, vegetables were cultivated in the trenches by utilizing residual soil moisture. This integrated system efficiently utilizes available land, water, and nutrients, transforming low-productive wetlands into sustainable and diversified farming units.

Performance and impact of technology: Under the conventional system, a farmer could earn only about ₹30,161 /hectare / year by growing paddy and greengram (Table 14). Implementation of the BBT system converted such low lands into multi-cropping systems, with half of the land as raised beds for year-round vegetable cultivation and the other half (trenches) serving as water bodies for fish farming and irrigation. This system helped to increase net income by tenfold that is to about ₹3.03 lakh per hectare per year. The cropping intensity increased by 300%, with successful integration of vegetables, fish, and residual moisture cropping. This technology helped the farmers to achieve year-round employment and a substantial improvement in livelihood security.

Table 14: Performance of broad bed cum trench system over farmers' practice (₹ ha^{-1} year^{-1})

Intervention	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Broad Bed cum Trench System	28*	2,16,795	5,20,208	3,03,413	2.45
Farmers Practice	3.6	32,787	62,949	30,161	1.90

*Crop Equivalent yield (Rice) of rice, bittergourd , fish and chilli



Model of broad bed cum trench



Bitter gourd and fish



Brinjal and paddy

Land shaping: Enhances climate resilience and farm productivity in the Sundarbans

Climate vulnerability: Moisture stress

Background: The coastal regions of the Sundarbans in West Bengal are characterized by flat, low-lying lands that remain waterlogged during the monsoon (*kharif*) season due to poor natural drainage and saline water intrusion. This condition restricts crop choice to low-yielding, deep-water rice varieties. Conversely, during the *rabi* and summer seasons, the same lands face acute water scarcity, making crop cultivation and livestock rearing nearly impossible.

This dual challenge of seasonal water stagnation and water deficit has been a major constraint to achieve sustainable agricultural productivity and livelihood security. To address these problems, Ramkrishna Ashram Krishi Vigyan Kendra (RAKVK) conceptualized and developed the Land Shaping Technology, an innovative intervention designed to improve drainage to address the water stagnation during rainy season and water scarcity in the *rabi* and summer seasons by rain water harvesting, enabling farmers to practice multiple and integrated farming systems without disturbing the groundwater table.

Details of technology: In land shaping technology, 1/5th portion of the flat low land is dug up to make a pond of 8-9 feet depth. The excavated earth is utilized for raising the rest of the low land upto a 1.5 feet height. The land embankment around the entire land is strengthened by increasing the land embankment to 3 feet height and 5 feet wide. With the remaining soil, a 5-feet wide and 4-feet high pond embankment is created. The low yielding traditional deep water paddy varieties in the *kharif* season are replaced with short duration HYV paddy and vegetables . Both these crops are introduced in the same land. Both the widened pond embankment and the land embankment were used for vegetable cultivation throughout the year. At the same time, pisciculture with duck rearing is taken up in the pond. In the NICRA villages, a plot of 0.26 ha was land shaped plot with a pond of 0.05 ha. Submergence tolerant, short duration (115 days) and high yielding rice variety Ciherang Sub-1 was grown on the elevated land (0.18 ha).Okra (0.01 ha) and bittergourd (0.01 ha) were planted on land embankment and bottle gourd (0.01 ha)on pond embankment during *Kharif* season. In winter, brinjal and chilli were grown on the main field (0.15 ha) and land embankment (0.03 ha), respectively. In summer, Cucumber was cultivated on the main field (0.17 ha). Mixed fish farming was taken up in the pond (0.05 ha), throughout the year. Whereas in the "farmer's practice" rice variety Dudheswar was grown on 0.26 ha plot under medium land situation (1.5 ft water stagnation), during July to November. Lathyrus was sown as paira crop on 0.1 ha area.

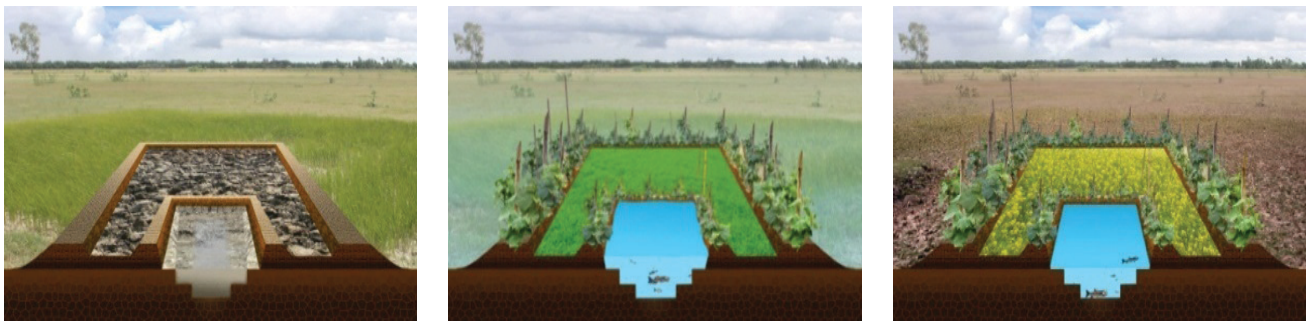
Performance and impact of technology: In 2010 encountered two cyclones (Fani in May and Bulbul in November), intensive rainfall (120 mm and 94 mm), prolonged submergence after transplantation of rice (August), and dry spells of more than 10 days (June and July), untimely

rain (February and November) and 39% deficient rainfall in *kharif* hence this year was considered as a stress year. Whereas 2018 year was taken as "normal year". The land shaping offered scope of multiple cropping to the farmers as the cropping intensity increased to 254%. The elevated terrain became suitable for growing short duration HYV rice. The vegetables, grown on the raised embankment were saved from prolonged water stagnation during intensive rainfall. The harvested rainwater in the pond was used for irrigation during dry spells in 2019 and sustained fish cultivation was done throughout the year. Assured irrigation allowed to grow vegetables in winter and summer season.

Both during a normal year and stress year the average net income was ₹ 85,974 and ₹ 71,738 higher from the land shaping over the farmer's practice. Even after Bulbul cyclone (November, 2019) the farmers whith land shaping had a minimum crop loss due to improved drainage and harvest of their short duration rice. These farmers could also take up *rabi* vegetable in time, whereas there was 25-30% loss of rice and 100% loss of lathyrus under farmer's practice (Table 15). Land shaping has been reported to maximize farm income, even during stress years.

Table 15: Performance of land shaping over farmers' practice (₹ 0.26 ha^{-1} year^{-1})

Intervention	Weather	Production (t) in different season			Cost of cultivation (₹)	Gross returns (₹)	Net returns (₹)	BC ratio
		Kharif	*Rabi*	Summer				
Farmers practice (0.26 ha)	Normal year	Rice: 0.684	Lathyrus: 0.036	Fallow	6,272	13,377	7,105	2.13
	Stress year	Rice: 0.555	Lathyrus: total crop loss	Fallow	6,015	9,990	3,975	1.66
Land shaping plot (0.26 ha)	Normal year	Rice: 0.828 Okra: 0.132 Bittergourd: 0.327 Bottlegourd: 0.305	Brinjal: 4.77 Chilli: 0.312	Cucumber: 1.858 ± 0.24	50,051	1,43,130	93,079	2.92
		Fish: 0.150 ± 0.01 (year round)						
	Stress year	Rice: 0.774 Okra: 0.130 Bittergourd: 0.305 Bottlegourd: 0.204	Brinjal: 4.308 Chilli: 0.271	Cucumber: 1.342 ± 0.16	54,420	1,26,157	71,738	2.32
		Fish : 0.142 ± 0.01 (year round)						



Model of land Shaping and rain water harvesting technology



A lowland in summer season



A land shaping plot



HYV paddy in land shaping plot



Winter vegetables on land shaping plot

Scope for upscaling: Over the last 10 years, more than 6,000 units of land shaping technology have been implemented by the RAKVK South 24 Parganas and adjoining district, through convergence of various Government sponsored schemes, like RKVY, IWMP, BGREI, NWDPRA, ATMA, etc. The technology can be further scaled up by integrating it to the various programmes of the state and central government.

Land shaping: A climate-resilient option for coastal landholders

Climate vulnerability: Soil salinity, cyclones, tidal changes, and saltwater intrusion

Background: After 2004 Indian Ocean tsunami, the agricultural ecosystems of island regions such as South Andaman suffered extensive and long-term damage. The seawater inundation led to the deposition of salts and sediments, severely impairing soil fertility and drainage. Over the years, frequent cyclones, storm surges, and changing tidal patterns have further aggravated the problem of saltwater intrusion into agricultural lands, irrigation ponds, and groundwater resources. As a consequence, large tracts of once-productive paddy fields became highly saline and waterlogged, making them unsuitable for the cultivation of traditional rice varieties. The continuous exposure to saline water not only reduced crop yields but also disrupted the delicate balance of soil microbial activity and nutrient availability. Due to these, many farmers stopped rice cultivation altogether, leading to a decline in agricultural productivity and livelihood insecurity in coastal and island farming communities. Hence salt-tolerant crop varieties, improved land and water management practices, and climate-resilient farming systems to restore productivity and ensure livelihood resilience in these fragile coastal ecosystems is the need of the hour.

Details of technology: The Broad Bed and Furrow (BBF) system is a land shaping technique implemented under the NICRA project in the affected villages. This system involves making broad beds of 4-5 m width alternated with furrows of 5-6 m width and 1-1.2 m deep. The raised beds prevent seawater or rain-induced flooding from entering cultivated areas, while the furrows facilitate effective drainage, reduce soil salinity, and enable diversified farming such as vegetables on beds and rice-fish culture in furrows. Crops grown on the raised beds such as chilli and radish generated the highest economic returns, followed by bhindi–amaranthus and coriander–amaranthus combinations. In the furrows, the rice-azolla-fish integration system was cultivated.

Performance and impact of technology: The Broad Bed and Furrow (BBF) system effectively helped to convert previously unproductive, waterlogged lands into productive and cultivable plots. Rice-azolla-fish integration system helped to achieve a 300% cropping intensity, making efficient use of land and water resources. An initial investment of ₹ 1,00,000 per hectare for land shaping was successfully recovered within a single cropping season through vegetable cultivation. The net income during the first year reached ₹ 62,000 per hectare, while in subsequent years this system recorded a significant increase in returns to ₹ 1,17,000 /ha, from continuous vegetable and fish farming (Table 16). This intervention not only enhanced farm productivity and profitability but also ensured year-round livelihood opportunities for small and marginal farmers in coastal lowlands.

Table 16: Impact of Broad Bed and Furrow (BBF) technology

Intervention	Area (ha)	No. Farmers	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	BC ratio
Farmers practice	26	63	54,875	60,920	6,045	1.11
Demo	11	11	89,000	2,23,400	92,480	2.51

Scope for upscaling: The BBF system can be upscaled through state and central government programmes in island conditions to manage post-tsunami saline and waterlogged soils. The approach supports year-round diversified farming, enhancing livelihood security and reviving agro-biodiversity.

2.2 Promising Crop Production Technologies

Climate-resilient nursery management of boro paddy to reduce cold injury and conserve water

Climate vulnerability: Flood and Cyclone

Background: Boro paddy is widely cultivated in certain pockets of Murshidabad district of West Bengal and the adopted villages under NICRA project. It is mainly cultivated in medium to low land with irrigation facility. Cold injury and high-water use are the main problems for boro paddy nursery. In addition, slow growth of seedlings which increases duration of the crop.

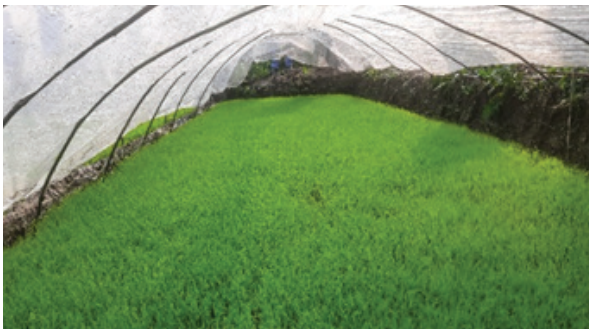
Details of technology: The seed bed for boro paddy was raised under poly tunnel to avoid cold injury. The poly tunnel structure was made with split bamboo and transparent polythene of 45 GSM. Vermicompost and ash has been mixed with the soil to increase water holding capacity.

Performance and impact of technology: The demonstrations were conducted in farmers' fields in the adopted villages. The nursery time under polytunnel has been reduced by 20% which may be due to increased temperature under poly tunnel. This method of rice cultivation reduced the water use by 40% (Table 17). The chlorosis due to cold injury was observed in the control plot whereas no such chlorosis was observed in the nursery under poly tunnel.

Table 17: Impact of nursery management under poly tunnel at Murshidabad

Intervention	Planting time (days)	Average soil temperature	Average yield (t ha^{-1})
Poly tunnel nursery	40 - 42	16	6.4
Control	57 - 62	12	5.8

Scope for upscaling: The technology can be spread to all the districts through convergence with state departmental activities, central programmes and ATMA.







Healthy seedlings in poly tunnel



Cold injured seedling in open condition

Floating rice seedbed - A climate resilient technology for low rainfall

Climate vulnerability: Flood and Cyclone

Background: The low rainfall in the recent times is a major concern in North 24 Parganas the district during the nursery preparation. IMD has reported 51 % deficit rainfall during July-August which caused delayed seedbed preparation of rice as well as rice cultivation. Delayed cultivation would lead to reduction in rice yield.

Details of the technology: To raise the nursery in time, North 24 Parganas Krishi Vigyan Kendra has introduced floating seed bed nursery for rice which is installed in fresh water canal and rainwater harvesting structure at NICRA village. The floating seedbed is made up of bamboo side walls. Thermocol and rice straw were placed under the bamboo structure to make it float. Transparent perforated (10%) polythene is used as seed bed substratum. A seed bed of 6-inch height was made with a mix of vermicompost and soil in a ratio of 3:1.5. The economic model should be of 9 ft L x 6 ft W which will help to produce seedlings for 0.325 ha area rice cultivation. 500 gm rice seed lings were placed on the floating patches of croplands. N:P: K (20:20:20) can be sprayed (200gm in 10 lit water) and 100 gm urea after 8 days. In this floating seedbed the seedling is grown for 12 days duration.

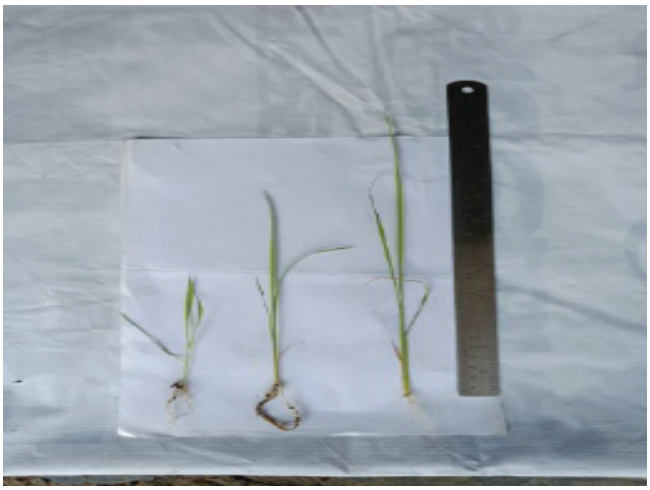
Performance and impact of the technology: In the NICRA village, Samsernagar of Hingalganj block, 90% rice area is under low land, saline prone, flood prone and single cropped. Rice is grown only in *kharif* season. Considering the fact of low rain fall and have seedlings in time for transplanting in time, Krishi Vigyan Kendra has introduced floating seed bed nursery for rice which is installed in fresh water canal and rainwater harvesting structure at NICRA village. The seedlings grown from the floated seed bed are transplanted in the main rice fields. The timely and full use of floating seedbed in deficient rainfall was the advantage. The farmers in the village were interested in the floating seedbed technique This technique is advantage both during deficit rainfall as well as in short term floods (Table 18).

In this method the germination of seeds was higher. The growth, vigor was higher. In addition to this the net returns from this nursery is higher as the cost of raising seedlings was lower.

Table 18: Impact of Floating Rice Seedbed technology over conventional seed bed:

Intervention	Seed germination (%)	Emergence of 2nd leaf (Day)	Root length (cm)	Organic matter (g kg^{-1})	Cost of seedling production (₹ ha^{-1})	Net returns (₹ ha^{-1})
Conventional rice seed bed	93	09	3.2	11.2	14,900	4,350
Floating Rice Seedbed technology	98	07	5.7	12.9	10,550	

Scope for upscaling: This technology has been upscaled widely through the State Agriculture Department through RKVY project 2023-24 and 120 demonstrations were taken up in the six coastal blocks in North 24 Parganas district.







Floating Rice Seedbed at North 24 Parganas

System of Rice Intensification - Opportunity for doubling the income

Climate vulnerability: Moisture stress

Background: In Purulia district of West Bengal rice is the main crop and cultivated over an area of 313.7 ha. The erratic and uneven distribution of rainfall causes poor yield.

Details of the technology: SRI technology of rice cultivation was introduced in the NICRA villages. This method requires less water and other resources but gives higher yield in comparison to the normal practice of rice cultivation. In this technology 5-5.5 q of farm yard manure and well rotten cow dung manure was applied per 0.1 acre land for better seedbed preparation. The seed was sown at the rate of 1.5-2 kg for one acre of land. 8-12 days old or three leaf stage seedlings were transplanted. single seedling was transplanted at a spacing of 25 x 25 cm spacing. After 8/10 lines of transplanting one line is skipped. FYM @ 1 ton $acre^{-1}$ was applied during final land preparation and 40 kg $acre^{-1}$ IFFCO 10:26:26 fertilizers before transplanting as basal. Within 72 hours of transplanting pre-emergence herbicide, Pretilachlor @500 ml $acre^{-1}$ was applied for weed control. At 21 DAT cono-weeder is used for weed control followed by top dressing with urea @ 30 kg urea/acre. Second top dressing of urea and MOP @15 kg and 10 kg $acre^{-1}$ respectively were applied at 45 DAT.

Performance and impact of the technology: In the district like Purulia where erratic rainfall, heat wave, severe moisture stress climatic vulnerability the SRI method of rice cultivation recorded 20–25% higher yield as compared to conventional transplanting method (Table 19). In addition to higher yield the cost of cultivation is reduced due to low seed rate, labour requirement and pesticide requirement. The seed rate is low as compared to conventional transplanting method. In normal method, the seed rate was 50-60 kg ha^{-1} but in SRI it is only 3.5-5 kg seed is required. In normal transplanting method hand weeding is done and in one acre of land 10 number of labour is required for two times weeding, but in case of SRI cono-weeder is used and only 03 labour were required. 10-15% lower pesticide is required as compared to the normal transplanting method. The GHG emissions also were reduced due to SRI cultivation as compared to normal transplanting method.

Table 19: Impact of SRI method

Intervention	Yield (t ha^{-1})		Increase %	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
	Demo	Normal				
System of Rice Intensification (GB-1)	6.66	2.25	196.52	60,503	59,377	1.98

Scope for upscaling: The technology has become popular not only among other farmers of NICRA village but also dispersed in adjoining 6 villages of Makrabers, Shitalpur, Dubcharka, Jambad, Chirumarcha and Sanradi. In the first year, we have demonstrated the efficacy of SRI technology only in 1.52 ha land of NICRA village which have been taken by other 15 farmers of NICRA village over an area of 7.45 ha in the next year and have also been adopted by about 55 farmers of adjoining villages over an area of 10.25 ha.





SRI method of rice cultivation at Purulia

Direct seeding of *kharif* rice

Climate vulnerability: Moisture stress

Background: In traditional rice cultivation methods, 40% of the world's irrigation water is applied for rice production. Increasing water scarcity due to climate change and competition from urbanization is making this traditional method of rice production unsustainable in the long term. Combined with other factors like shortage of labour and decreasing arable land.

Details of the technology: Direct seeding of rice should preferably be practiced on medium to heavy textured soils as the soil moisture retention was higher. Whereas, in light textured sandy soils are more prone to iron and zinc deficiency, and has low water retention which resulted in reduced yields. Sowing method in DSR and herbicide efficacy (pre-emergence) is highly influenced by soil type. The field is prepared and then levelled. Direct seeding of rice was done with tractor drawn implement at a spacing of 20cm x 20cm. The rice seed should not be placed deeper than 2.5 cm to maximize uniform crop establishment. For the successful direct seeding system, it is necessary to select short duration rice cultivars that can produce high yields in aerobic conditions. Cultivars should be weed competitive, tolerant to moisture stress in early growth stages and should have greater translocation efficiency after flowering. Sahabhagi Dhan is a suitable variety for DSR. In Purulia, rice is mainly grown during the monsoon season, establishment of direct-seeded rice can be adversely affected by untimely rains immediately after sowing. Emergence is poor if continuous rain prevails immediately after sowing or because of the mortality of young seedlings caused by submergence. Hence direct seeding was tried in uplands.

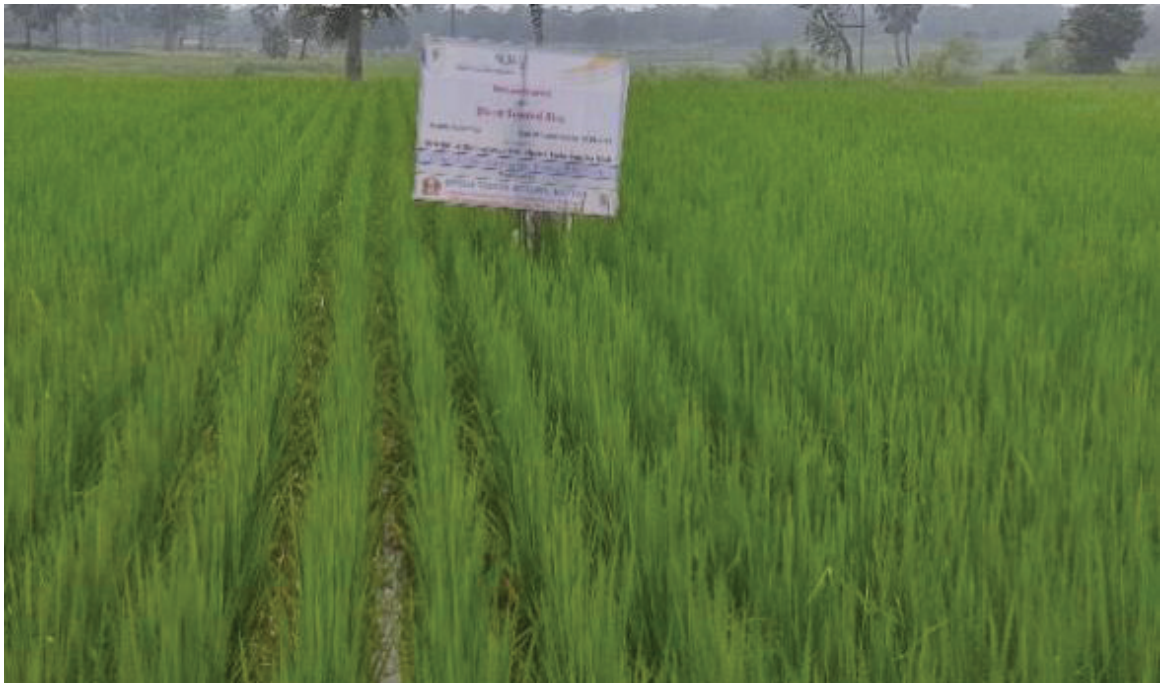
Performance and impact of the technology: In the uplands of Purulia district the normal transplanting method of rice gives very poor yield and sometimes the crop completely fails due to low rainfall. The direct seeding of rice records higher yields (Table 20). The higher yields were recorded if timely weed control is done. The cost of production is low compared to normal transplanting method. The farmers readily accepted this technology.

Table 20: Impact of direct seeded rice on productivity and returns

Intervention	Yield (t ha^{-1})		Increase %	Cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
	Demo	Normal				
Direct seeding of *kharif* rice (Sahabhagi Dhan)	48.75	22.46	117.05	59,420	28,330	1.47

Scope for upscaling: It is seen that the villagers of NICRA adopted village are very confident to do the practice. The adjoining villagers also accepted this technology. The technology can be spread through convergence with other state government programmes. Implement can be made available through custom hiring centre.





Direct seeding of paddy at Purulia

Improved sugarcane varieties for waterlogged and moisture stress conditions

Climate vulnerability: Flood

Background: In West Bengal sugarcane is the second most important commercial crop after jute. Farmers in this state have been cultivating sugarcane for many centuries for making gur and many sweets

Details of the technology: The adopted villages under NICRA project are situated in flood prone area and nearest to the river The Ganges. Recurring incidence of severe flood and incoming of huge water in crop land damaged the standing crop of sugarcane. The traditional indigenous varieties of sugarcane are susceptible to waterlogged condition and to insect pests the crop is damaged. As a result, the yield and income of the farmers were very low.

Performance and impact of the technology: To overcome this problem, in NICRA adopted villages the Malda KVK introduced two improved sugarcane varieties (Swapan and Birendra) which are moderately resistant to red rot, wilt smut, tolerant to common borer insect pests and also tolerant to both water submergence and drought. These two verities recorded -34 and 38 % higher yield in normal and stress years respectively (Table 21). The average yield of these two varieties of sugarcane is 80-88 tons per hectare and average sugar content in juice is about 16.8-17.5 percent. Average cost of cultivation of sugarcane in farmers field is ₹ 75,000 to 90,000 per ha and average profit is ₹ 1,50,000 for a good sugarcane. The villagers accepted the technology and a spread in the technology was observed. These two varieties were cultivated in 5.0 hectare land and benefited 50 farmers.

Table 21: Impact of varietal improvement of sugarcane cultivation in NICRA villages

Intervention	Year	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Improved variety	Stress year	82.7	62,500	1,87,500	1,25,000	3.00
Local variety		60.0	65,810	1,58,611	92,801	2.41
Improved variety	Normal year	90.0	55,120	2,02,736	1,47,616	3.67
Local variety		67.0	57,950	1,55,338	97,388	2.68

Scope for upscaling: The technology can be spread to the entire districts through convergence with state departmental activities, central programs and ATMA.







Introduction of improved sugarcane varieties at Malda district

Millets – A new opportunity for degraded upands

Climate vulnerability: Moisture stress

Background: Millets is a re-introduction in the NICRA adopted village. In Purulia district 30% of the land is un-bunded uplands (locally called 'Tar'). Where the water holding capacity of the soil is very low and the soil fertility is very low. The major land area is culturable fallow.

Details of the technology: Finger millet (var.- Indravathi) is an alternate crop for these lands during *kharif* season as finger millet is one of the most climate resilient crop that gives higher yield even in moisture stress condition and poor soil fertility conditions. Seed bed was prepared and to this seed bed organic manure was added. The seed rate required was 7 kg ha^{-1}. Before sowing the seed in the seed bed seed treatment with Bavistin was done and sowing was done in the prepared seed bed. 25-30 days old seedlings were transplanted into the main field at a spacing of 20cm x 10cm. 75 $kgha^{-1}$ of IFFCO 10:26:26 complex fertilizer was applied as basal followed by 40 kg ha^{-1} urea was applied at 25 DAT onwards when water is available.

Performance and impact of the technology: In Taar land (unirrigated and unfertile land) finger millet cultivation can be successfully grown. The farmers will get average 1.40 t ha^{-1} yield (Table 22). The cropping intensity can be increased in the marginal lands. The demand of the millet is increasing day by day for its good nutritive value. The demand of the millet powder in the market is very high.

Table 22: Demonstration on Finger Millet

Intervention	Yield (t ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Finger millet (Indravathi)	1.40	61,387	2.66
Farmers' practice (local practice)	0.94	40,650	1.4

Scope for upscaling: The technology is well accepted by farmers from NICRA villages. Non-NICRA farmers from nearby villages also accepted the technology and the NICRA village farmers sell their seeds from their seed banks. These farmers very enthusiastic to introduce finger millet crop and taken up this crop over an area of 25 ha in the next season.



Finger millet (var. Indravathi) as an alternate crop at Purulia

Vegetables based multi-tier horticulture system

Climate vulnerability: Flood

Background: Farmers generally cultivate seasonal crops. Unpredictable change of weather many times damage the standing crops which reduces the productivity and profitability of the farmers.

Details of the technology: When farmers plant single climber crop in bower system made by bamboo structure most of the land remain unutilized. In this situation Multi- tier cropping system opens a new door to earn round the year as well as there is low risk of complete crop failure. Multi-tier cropping systems are dynamic interactive practices that better use of the production components such as soil, water, air space, solar radiation and all other inputs on sustainable basis to take full advantage of limited land resources. At first about 5-6 ft height structure is made by bamboo on which climbers like cucumber, bottle gourd, bitter gourd, snake gourd are grown. In this system the tallest components require strong light and high evaporative demand whereas shorter components are shade loving.

Under the structure different vegetable crops according to their height can be grown. Under the structure land should properly ploughed and prepared plots and irrigation channels. The soil of plots is mixed with fertilizer and manures according to crop requirement. Vegetables which are selected for multi-tier cropping system like leafy vegetables (coriander, spinach, radish, amaranthus) tomato, brinjal, chilli and even elephant foot yam may also be grown. All growing space is used as crop fit together vertically or horizontally (tall, medium & short) and underground (deep-rooted and shallow-rooted plants). Seasonal crops with high market preference can be cultivated.

Performance and impact of the technology: The technology is highly potential because it uses natural resources properly. Farmers are highly interested to adopt this technology because production per unit area of land, time and inputs can be increased with multi-tier cropping system and reduces the insecurity of mono-cropping resulting in higher productivity and profitability. The productivity and net returns during normal year was 84.2 t ha^{-1} and ₹ 1,12,060 ha^{-1} respectively and stress year was 72.0 t ha^{-1} and ₹ 78,500 ha^{-1} respectively (Table 23).

Table 23: Impact of Multi-tier Horticulture on vegetables cultivation in NICRA villages

Intervention	Year	Yield (t ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	BC ratio
Multi-tier cropping	Stress year	72.0	82,250	1,60,750	78,500	1.95
Mono cropping		52.2	97,023	1,30,200	33,177	1.34
Multi-tier cropping	Normal year	84.2	70,260	1,82,320	1,12,060	2.59
Mono cropping		60.0	73,502	1,35,233	61,731	1.83

Scope for upscaling: The technology can be spread to the entire districts through convergence with state departmental activities, central programmes and ATMA.







Vegetables based multi-tier horticulture system

Income generation to rural women: Milky mushroom cultivation

Climate vulnerability: Moisture stress

Details of the technology: Milky Mushroom cultivation was introduced as an income generation activity at NICRA adopted village Haramjanga, Purulia district. Initially, two days hands on training were conducted on mushroom cultivation. After the training two interested and enthusiastic Self-Help Groups were selected. Paddy straw was chopped it into 2-3 inch (50 kg paddy straw) and was soaked for 12-14 hrs. In water formaldehyde (120 ml/200 lit. water) + fungicide (Bavistin 7.5 gm/100 lit water) + lime 250 gm/200lit water was added. After sterilization of paddy straw, the wet paddy straw is placed as a thin layer to drain out the excess water under shade on a clean polythene sheet. Milky mushroom has higher biological efficiency the total weight of paddy straw used per bag will be transformed into mushroom weight under good management conditions. In polythene bags of 18cm x 20cm 1.25 kg straw and 200 gm of mushroom spawn can be used.

The cylinders are prepared by layering the straw topped with mushroom spawn in each layer and each layer can be 3-inch height, four such layers can be placed in a cylinder. The air is compressed out using hand. The mouth of the cylinder is closed with rubber band or thin rope. In the cylinder at 10-12 places holes may be made to facilitate draining out excess water and watering the cylinder in future. The cylinders are then kept into clean dark room for mycelium growth. After about 7 days the cylinders are prepared in the soil. The soil used for the casing cylinder are to be prepared using two parts of compost, one part of garden soil and one part of fine sand. These are mixed thoroughly and then sterilized with water mixed with formaldehyde and lime. The cashing soil mixture is heaped and hole is made in centre through which lime and formaldehyde mixture is poured and covered from top with carving soil and entire mixture is covered with polythene and kept for 3-4 days. When the cylinder turns white after mycelial growth the rubber from top is removed and mouth of cylinder is opened.

The cashing soil is evenly placed on the top of the cylinder to a height of 3-4 inch and light watering is done from top. The cylinders are now placed in a well air circulated room where light is available during the day time and watering is to be done once every day with the help of water cane on the top of the cashing soil. After around 12-15 days white mushroom buds emerges from within the cashing on top of the cylinder. Then harvesting was done after 3-4 days. At harvest the mushroom is cut from the base with the help of sharp blade. The village women initiated mushroom cultivation with 50 packets each.

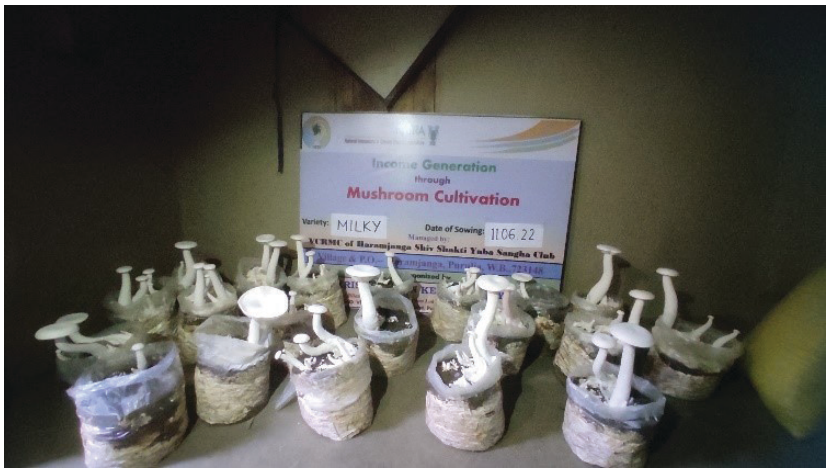
Performance and impact of the technology: The farmers recorded 0.78 quintal of milky mushroom (Table 24). These mushrooms were sold in Purulia town market @ ₹ 150 kg^{-1}. the quality of the mushroom is very good hence the demand for the mushroom is very high. The women in the village were enthusiastic and interested in mushroom cultivation as they are getting additional income. Usually, the women of the village were doing field operations as a labour in their own field. Hence, they do not get any income. So, that they eager to catch the opportunity for getting additional income in their leisure period. The women farmers extended their cultivation to oyster, paddy straw mushroom and also and get significant income. Apart from the mushroom cultivation they are imparting training to women from nearby village by generating interest

Table 24: Milky mushroom cultivation

Intervention	Yield (t 50 bag^{-1})	Cost of Cultivation (₹ 50 bag^{-1})	Net returns (₹ 50 bag^{-1})	BC ratio
Milky Mushroom cultivation	0.078	3,350	8,350	3.49

Scope for upscaling: Two women groups have started the mushroom cultivation. These women SHG groups have trained the farmers from adjoining three villages.





Income generation to rural women through milky mushroom cultivation

Accelerated jute retting for superior fiber quality

Climate vulnerability: Flood & Cyclone

Background: Jute is the most important agricultural cash crop in Murshidabad district, West Bengal covering 1,01,800 ha area. Farmers of the district water deficit due to 60 % deficit rainfall. In addition to water scarcity, faulty retting methods severely deteriorate jute fiber quality.

Details of the technology: In this back drop the following technologies was introduced. Hence, improved retting methodologies were introduced through training and demonstration in NICRA adopted villages. The jute retting with CRIJAF Sona and NINFET Sathi powder helps in better retting of jute and hastens retting process; thus, reducing retting time which reduces the defects in jute fiber. Furthermore, dipping the extracted fiber in 0.1% vizol polyquat solution for 1-2 minutes immediately after extraction from jute stick improves the color of the jute fiber.

Performance and impact of technology: A combination of above two technologies has reduced the retting time from 18 - 20 days to 10 - 12 days and also improved jute fiber quality from Grade TD-4 / 5 to Grade TD-2/3 which increased the price of jute fiber to the tune of ₹ 1000 - 1200 per quintal and as a result of which gross and net income of farmers increased by ₹ 21,000 and ₹ 16,500, respectively (Table 25). During 2022-23, Dhaanyaganga KVK (Murshidabad Additional) conducted 78 demonstrations covering 27.56 ha, which increased the farmers income to ₹ 19,600 ha^{-1} as compared to ₹ 15,750 ha^{-1} in non-NICRA farmers. It also increased the retting capacity of surface water area by 186% which in turn helps to manage drought.

Table 25: Impact of accelerated jute retting

Intervention	Retting time	Fiber quality	BC ratio
Improved Jute retting method	10 - 12 days	Grade 2/3	2.2
Traditional method	18 - 20 days	Grade 4/5	1.9

Scope for upscaling: The technology can be spread to the entire district through convergence with state departmental activities, central programmes and ATMA.



Accelerated jute retting

Bio-stimulants in vegetables: A climate-resilient strategy for managing abiotic stress in South Andaman district

Climate Vulnerability: Drought, salinity, and temperature extremes

Background: Vegetable crops in the South Andaman region are highly vulnerable to multiple abiotic stresses such as drought, salinity, and high temperatures, which adversely affect productivity and profitability. Traditionally, farmers have relied on chemical fertilizers to improve yields; however, excessive use has led to soil health deterioration, nutrient imbalance, reduced microbial diversity, and increased pest and disease incidences. To mitigate these issues, bio-stimulants such as humic acid, fulvic acid, and amino acids have emerged as sustainable options. These compounds enhance soil fertility, nutrient use efficiency, root growth, and physiological resilience of plants under stress. When used in combination with farmyard manure (FYM) and other organic manures, bio-stimulants helps to maintain soil structure, microbial activity, and crop performance even under adverse conditions.

Details of technology: Application of humic acid-based bio-stimulants in vegetable crops like brinjal and tomato to enhance their tolerance to abiotic stress and improve productivity. Enriched organic manures were integrated with bio-stimulants for improving soil health and nutrient availability. The treatments included recommended doses of bio-stimulants applied at critical crop growth stages along with organic amendments.

Performance and impact of technology: The application of humic acid, fulvic acid, and amino acid-based bio-stimulants resulted in noticeable improvements in crop vigor, flowering, and fruit set under stress conditions. Yields of brinjal and tomato increased by 20 and 19% as compared to farmer's practice (Table 26). In addition better soil health indicators and reduced input costs over time was observed. Economically, farmers achieved higher net returns and benefit-cost ratios, indicating the viability and sustainability of bio-stimulant integration in vegetable production systems. The intervention also demonstrated the potential to reduce dependency on chemical fertilizers while improving resilience of smallholder farming under changing climatic conditions.

Table 26: Impact of bio-stimulants on vegetable crops

Intervention	Yield (t ha^{-1})		% increase	Economics of demonstration (₹/ha)		
	Demo	Local		Gross cost	Net returns	BC ratio
Abiotic stress management through bio-stimulants in Brinjal	10.25	85.3	20.2	1,26,700	3,34,550	3.64
Abiotic stress management through bio-stimulants in Tomato	11.9	100	19.0	1,87,500	4,07,500	3.17

Scope for upscaling: Scope for Upscaling: The technology is cost-effective and easily adoptable across vegetable-growing regions of the islands. It can be promoted through Farmer Field Schools (FFS), Farmer Producer Organizations (FPOs), and organic farming initiatives to enhance productivity, profitability, and soil resilience under the NICRA and organic Island programs. Furthermore, this technology can be scaled up through state and central government schemes, particularly in regions facing soil fertility constraints and environmental stress conditions, to promote climate-resilient and sustainable vegetable production'.



Bio-stimulant applied tomato crop



Bio-stimulant applied brinjal crop

2.3 Promising Livestock Production Technologies

Agro silvi pastoral agroforestry system – A model IFS to combat climate uncertainty

Climate vulnerability: Flood & Cyclone

Background: By integrating trees with crops and livestock, agroforestry systems create a symbiotic ecosystem that can lead to heightened economic and ecological benefits.

Details of the technology: In the challenging era of self-reliance, combination of goat farming with agro-forestry was introduced in the village Bali, Murshidabad, West Bengal. Forest trees, including segun, mehagani, neem, and fruit trees like jackfruit, mango, and guava were introduced. The remaining land was transformed from pasture land to cultivable land, employing agrotechniques for diverse crops such as cereals, pulses, vegetables, fibre crops, and oilseeds. Dhaanyaganga KVK provided essential technical assistance, guiding the farmers on land utilization, housing, managerial aspects, economic strategies, and program planning. For the integration of goat farming the superior breed of goats, deworming, vaccination, and advice from mobile veterinary clinics were recommended.

Performance and impact of technology: The farm operates as an integrated system, creating a bio-economic circularity where components co-habit and heavily rely on each other. Waste materials from one component serve as inputs for another, resulting in significant economic savings. For instance, fruit crop leaves are a reliable feed for goats and cattle, saving up to ₹12,000 annually (Table 27). Forest tree leaves are used for composting, reducing the need for conventional organic manure and saving ₹ 2,00,000 per year.

The economic viability of the farm is evident in the production, expenditure, gross income, and net income of different components. For cereals, pulses, fiber crops, oilseeds, fruits, and other enterprises like goat farming and vermi-composting, the farm exhibits positive net returns.

Table 27: Impact of agro silvi pastoral agroforestry system-based animal husbandry

Component	Area (ha)	Production (kg)	Expenditure (₹)	Gross income (₹)	Net income (₹)
Cereal (Rice, Maize, Wheat)	0.47	5,357	36,429	1,28,571	92,143
Pulse (Lentil, Biuli, Bengal Gram)	0.40	1,700	11,875	1,22,500	110,625
Vegetables/ Spices	0.07	6,300	30,000	1,23,750	93,750
Forest Trees	0.53	4,500	15,000	78,750	63,750
Fruit Plants	0.13	10,500	22,500	1,12,500	90,000
Fiber Crops/ Oilseeds	0.80	2,750	56,250	1,88,750	1,32,500
Cattle (Jersey Cross)	1 N	2,000 L	33,650	80,000	46,350
Goat (Black Bengal)	43 N	-	-	1,10,000	1,15,000
Other Enterprise	0.27	30,000	31,875	75,000	54,375

Scope for upscaling: The integrated farming system with the goat-centric agro-forestry model, can transform the fate of distressed farming community in the face of changing climate. Dhaanyaganga KVK's continuous support in managerial advice, technical supervision, and financial inclusive policy-making played a pivotal role in the success this venture.

With the right guidance and dedication, distressed farming communities can turn adversity into success, paving the way for a brighter and more sustainable future in agri-entrepreneurship.





Agro-silvi-pastoral agro-forestry system based animal husbandry

Backyard pig farming for enhanced profitability

Climate vulnerability: High rainfall

Background: Pig rearing is an important means of livelihood for the tribal population in the North-Eastern Region of India. Pig farming has been identified as one the key areas for poverty reduction and agri-business venture.

Details of technology: Farmers of NICRA project adopted village Singimari of Cooch Behar District of West Bengal is presently realizing a net income of ₹ 1,32,000/- per annum from piggery units. Success from these piggery units attracted other farmers of the nearby villages. Farmers planted oats, hybrid napier, hydroponic fodder etc. for feeding the pigs. They constructed thatched sheds in the backyard with semi-concrete flooring and compartments with an average capacity of 5 sows and 20 piglets at a time. Scientists from Cooch Behar Krishi Vigyan Kendra, UBKV, West Bengal inspired them to start the unit and assured all possible technical guidance.

Performance and impact of technology: Under NICRA project KVK provided six Ghungroo piglets (1 male & 5 female) to the farmer. Within 11 - 12 months each sow delivered 8 - 12 nos. of piglets in the first batch. The piglets were reared up to 70 - 80 days of age and sold at ₹ 3,500 - 4,000 each. The farmers on an average sold 80 nos. of piglets in a year. They disposed the 5 nos. old pigs for pork and the remaining piglets were retained as parental stock. The old pigs were also sold at ₹ 15,000 - 16,000 each depending upon the body weight. They spend around ₹ 2,000 - 2,500 per month on purchasing some of the feed ingredients like broken rice, rice bran, medicines, vaccines etc. They also used left-over rice, kitchen waste etc. for feeding of pigs. Besides this oats, hybrid napier, hydroponic fodder etc. were cultivated for feeding of pigs. The family members were also engaged to look after the pigs.

Scope for upscaling: Pig breeding has become a successful model in the village. Many farmers from the District of Cooch Behar visit these farms for piglets. Farmers are more interested to rear pigs in Cooch Behar district. This piggery rearing can be scaled up by making available to the farmers through FPC, farmers by the state government and central government.





Backyard Pig Farming at Cooch Behar district

Area-Specific mineral mixture: A key to livestock productivity and climate resilience

Climate vulnerability: Moisture stress

Background: Problem of mineral deficiency and metabolic disorder in all categories of dairy animals have been reported due to lower content and low bio-availability of minerals in feed stuffs. There is need for the supplementation of area specific mineral mixture to dairy animals.

Details of technology: Mineral mixture contains all the essential minerals in required quantities. Supplementing mineral mixture will help in improving growth rate in calves, increasing milk production, reducing cold stress, improving reproductive efficiency, reduce calving interval and increase productive life of dairy cow and improve immunity. It can be given at the rate of 50g/ day/animal once in a day along with the animal feed. It will improve overall animal health and immunity and productivity during stress.

Performance and impact of technology: The use of mineral mixtures has not only helped in increasing the milk yield but also alleviated problems of anoestrus and repeat breeding to a large extent in NICRA village Paiyong, Kalimpong/Darjeeling District. In a demonstration involving 25 farmers with 55 animals, conducted in a NICRA village during 2022-23, an increased milk yield per day was observed with the animals being supplemented with balanced mineral mixture to an extent of 24.76% over local practice (Table 28). The mineral mixture recorded higher net returns (36.40%) and BC ratio (2.40%) than local farmer practice. Apart from this, body weight increased in calves by 7.25% over local practice was observed in NICRA village of Paiyong, Kalimpong/ Darjeeling District. This intervention is well adopted by the farmers of NICRA village, Paiyong, Kalimpong/Darjeeling District.

Table 28: Performance of mineral mixture supplementation to dairy cow in NICRA village, Paiyong, Kalimpong/Darjeeling District

Intervention	Milk yield (L day^{-1})	Cost of production (₹ day^{-1})	Gross returns (₹ day^{-1})	Net returns (₹ day^{-1})	BC ratio
Farmers' practice	5.25	97.75	210	112.25	2.15
Mineral mixture	6.55	109.29	262	152.71	2.40

Scope for upscaling: This can be upscaled widely through the animal husbandry department, National Livestock Mission and also by supplying them on subsidy. Local entrepreneurship can also be encouraged which can further contribute to upscaling.





Mineral mixture supplementation to cow in NICRA village, Paiyong, Darjeeling district

Mineral mixture supplementation: Enhancing livestock productivity and resilience

Climate vulnerability: Flood & Cyclone

Background: The livestock population in coastal saline area of Sundarban suffers from mineral deficiency in dairy animals due to lower content and low bio-availability of minerals in feed stuffs.

Details of technology: Mineral mixture acts as different precursor of body enzyme system which in turns increase the milk production. Supplementing mineral mixture will also help in improving growth rate in calves, reduces heat stress, improves reproductive efficiency and improve immunity. It can be given at the rate of 50g/day/animal in cows once in a day along with the animal feed.

Performance and impact of technology: The use of mineral mixtures increased milk yield and lowered the reproductive disorders significantly. A demonstration was conducted with 90 farmers with 180 animals, in a NICRA adopted village Samsernagar under Hingalganj block of North 24 parganas district. This mineral mixture increased milk yield by 12.5% in a day over local practice. This also increased net returns and BC ratio over the local practice. Apart from this, calves body weight was increased by 8.96% over local practice (Table 29). This intervention is well accepted; hence the usage of mineral mixture for animals has increased by 26.49% among the farmers in NICRA village. The intervention is well adopted by adjacent village dairy farmers.

Scope for upscaling: This can be upscaled widely through the animal husbandry department, National Livestock Mission and also by supplying them on subsidy. Local entrepreneurship can also be encouraged which can further contribute to upscaling.

Table 29: Performance of mineral mixture for enhancing productivity:

Intervention	No. of farmers	Unit/ No.	Milk production (kg)		% increase	Economics of demonstration (₹ animal^{-1})		
			Demo	Local		Cost	Net returns	BC ratio
Mineral mixture	90	160	4.5	4	12.5	1,080	720	1.66



Mineral mixture supplementation to cow and buffalo in Samsernagar village, North 24 Parganas

Low-cost azolla cultivation: A protein-rich green fodder for dairy and poultry

Climate vulnerability: Flood & Moisture stress

Background: The farmers face severe fodder shortage for the live-stock during the flood period.

Details of technology: Considering the farmers' problem, the farm families belonging to relatively upland situation were recommended to cultivate azolla as livestock feed. A small polythene sheet (4''x2'') is placed in small ditches nearby house or anywhere, one can produce azolla (1.5-2 kg per day after 10-12 days of installation), which can be used as green fodder for cattle and poultry birds as a protein supplement for upto three months.

Performance and impact of technology: The income of the farmers increased income by ₹ 20940 per animal /lactation with the use of azolla as green fodder for cattle and poultry birds as protein supplements. In case of milch animals, the milk productivity was 5.3 litre lactation^{-1} animal^{-1} day^{-1} with azolla feed as compared to 3.5 litre lactation^{-1} animal^{-1} day^{-1} feeding only dry fodder (51.42% increase in milk productivity lactation^{-1} animal^{-1}) (Table 30).

Table 30: Impact of azolla cultivation as green fodder for milch cow as protein supplements

Intervention	Milk yield (litre animal^{-1} year^{-1})	Cost of production (₹ animal^{-1} year^{-1})	Gross returns (₹ animal^{-1} year^{-1})	Net returns (₹ animal^{-1} year^{-1})	BC ratio
Productivity without azolla	420	6,000	16,800	10,800	2.8
Productivity with azolla	636	4,500	25,440	20,940	5.65

Scope for upscaling: This can be upscaled widely through the animal husbandry department, National Livestock Mission. Local entrepreneurship can also be encouraged which can further contribute to upscaling.



Low-cost azolla cultivation as green fodder at Malda district

Black bengal goats with low-cost housing: Climate-resilient and cost-effective management

Climate vulnerability: Flood & Moisture stress

Background: The farmers faced huge problems due to disease infestation of goat particularly due to PPR during rainy season. Almost every villager in the adopted villages have goat but they don't have proper goat shed. Therefore, mortality is higher in every village.

Details of technology: Black Bengal breed is one of the important breeds due to its high prolificacy, early maturity, low kidding interval and their delicious meat. It is most popular as a supplementary source of family income. Black Bengal goat is housed mainly for night shelter as well as during inclement weather. Though Bengal goat is typically a grazing animal, the animal's mortality is higher. Hence farmers were recommended to make in-house arrangement for feeding and watering during inclement weather. Farmers generally use materials (like bamboo, paddy straw and polythene sheet, etc) for construction of low-cost goat house which is cost effective.

Performance and impact of technology: Black Bengal goat gains body weight and can be disposed between 6 and 12 months of age. At the age of 12 months, Black Bengal goat produces best quality chevon. The cost of black Bengal goat (per kg live weight basis) is highest (on an average ₹ 500) in animals up to 12 months of age and lowest (₹ 250 to 300) in animals of more than 12 months of age, particularly females. The average cost per animal is ₹ 700 at 6 to 12 month age and average profit was increased by about ₹ 2,200 to 3,500 (Table 31). As a result, farmer's family consumption improved due to financial upliftment. By this cost-effective shelters, improved breed benefited approximately 50 percent farmers of the area.

Table 31: Performance of Bengal goat under low cost goatary house

Intervention	% of Mortality	Gross cost (₹ animal^{-1} year^{-1})	Gross returns (₹ animal^{-1} year^{-1})	Net returns (₹ animal^{-1} year^{-1})	BC ratio
Without Low-cost goatary house	45	1,050	3,000	1,950	2.8
With Low-cost goatary house	14	700	4,000	3,300	5.7

Scope for upscaling: This can be upscaled widely through the animal husbandry department, National Livestock Mission. Local entrepreneurship can also be encouraged which can further contribute to upscaling.



Low cost goatary house for Black Bengal goat at Malda district

Floating duck house - A climate resilient technical initiative to combat natural calamity in Sundarban delta

Climate vulnerability: Flood & Cyclone

Background: In Sunderban delta the main filed remains inundated due to low-lying as well as heavy rainfall with impeded drainage system and often breaching of river embankment after cyclonic storm is common.

Details of technology: In this situation duck rearing as a component in floating duck house in the water as a pond based integrated farming system concept is a novel idea, in this technology, a small low-cost duck house with a capacity of 20-25 numbers of ducks is made with locally available materials and floated over the pond. This duck house can be moved from one corner to another with a view to evenly distribution of wasted feed and duck droppings throughout the water body. These droppings would be fish feed. This technology also helps to protect the duck from wild predators apart from the additional profit and household nutritional security of the farmers.

Performance and impact of technology: The floating duck house is a good technology where mortality of the ducks due to natural calamity like flood etc. was reduced as well as it provides a profitable farming system as input cost for fish feed was reduced. A demonstration involving around 10 numbers of farmers with 200 ducks was carried out under NICRA project in Samsernagar village of North 24 Parganas district. (Table 32). The BC ratio was found better in tested group (1.67) than the farmer's practice (1.40). In farmers method the farmers will be in loss as the ducks die or missed due to flood. The technology is getting more popular and more numbers of farmers are showing interest to adopt this technology particularly in this village and surrounding villages.

Table 32: Impact of floating duck house technology in NICRA villages

Intervention	No. of farmers	Unit/ No.	Measurable indicators of output	Economics of demonstration (₹ ha^{-1})			
				Gross cost	Gross returns	Net returns	BC ratio
Farmer's practice	10	20	Shelter is destroyed after natural calamity	5,000	7,000	2,000	1.40
Climate Resilient Floating duck house	10	20	Shelter is sustainable after natural calamity	6,000/ unit	10,000	4,000	1.67

Scope for upscaling: The technology may be upscaled widely by the ARD of the particular district in the particular area.







Climate resilient floating duck house at North 24 Parganas

Super Napier Grass : A green fodder to alleviate animal stress and better production

Climate vulnerability: Flood & Cyclone

Background: Poor physical growth and low yield of crossbreed cow had been observed at the adopted village of Sundarban in North 24 Parganas district of West Bengal under NICRA project. In farmers practice, there was no practice of providing quality green fodder cultivation separately.

Details of technology: KVK introduced Super Napier as green fodder in the village and encouraged dairy farmers to use excess land, field bunds, pond banks to grow green fodder. Supplementation of green fodder in dairy cattle according to body weight is one of the management techniques for increased milk production, better gut health and relieve animal stress.

Performance and impact of technology: 10 farmers, who are holding at least 0.13 ha for cultivation of green fodder, were selected for the study. KVK supplied the fresh cuttings of Super Napier fodder for 0.13 ha and continuously monitored the cultivation on farmers' fields. It has been found that the unused land selected for fodder production had produced average 65 t ha^{-1} green fodder in one season (3-4 cut). It is also noticed that the skin lustier, appetite, digestion status, stress parameters along with other health parameters are improved through daily supplementation of green fodder. The average milk yield of lactating cow had increased by 15.97% through supplementation of green fodder (Table 33). Successful demonstration and introduction of green fodder minimized the health issues, stress which helped to increase milk production. The villagers are now able to supply fresh fodder cuttings to other farmers and neighboring villagers from their own fodder bank and thus technology had horizontally spread out.

Table 33: Impact of green fodder in NICRA villages

Intervention	Yield (t ha^{-1})		% increase	Economics of demonstration (₹ ha^{-1})		
	Super Napier	Local		Gross cost	Net return	BC ratio
Super Napier	65	32	100%	4,61,538	10,76,923	2.33

Scope for upscaling: The technology may be upscaled through agricultural department, animal resource department, ICAR institutions and SAUs through national livestock mission and different targeted projects to develop more village-based fodder banks.



Introduction of green fodder (Super Napier Grass) at North 24 parganas

Mass seed production of scampi (*Macrobrachium rosenbergii*) in brackish water pond in flood and cyclone prone areas

Climate vulnerability: Flood & Cyclone

Background: The giant freshwater prawn, *Macrobrachium rosenbergii* (de Man, 1879) popularly known as 'scampi', is the most economically important species of prawns farmed chiefly in small to medium-sized earthen ponds in Sundarban delta of West Bengal. There are 240 commercial shrimp hatcheries along both east and west coast of India which produces about 10-730 million seeds of the species for aquaculture (MPEDA, 2016). Hence, farmers still depend on collection of post larvae (seed) from natural brackish waters. These local verities develop serious collateral damage inflicted on non-targeted organisms, and also the collected wild post larvae do not fulfil the demand of present culture scenario.

Details of technology: To overcome this situation, North 24 Parganas Krishi Vigyan Kendra introduced a mass seed production of *M. rosenbergii* in brackish water inundated ponds with a stocking density of 5 kg berried female scampi (Salinity of the water 9-10 ppt) in 1000 m^2 area. The breeding period was 25-30 days; after that the post larval production will take place.

Performance and impact of technology: The seed production of scampi in brackish water pond is a good technology for livelihood generation of the fishermen and women folk and is climate resilient. A demonstration involving around 5 farmers were carried out under NICRA project in Samsernagar village of North 24 Parganas district. The BC ratio of the intervention was 4.14 (Table 34). The technique is adopted by most of the farmers due to 'low-cost and low-risk'. This increased interest in more number of farmers to adopt this technology particularly in surrounding villages. This package of practice will meet the demand of quality post larvae requirement, profitability as well as stop the bio-diversity loss due to by-catch.

Table 34: Impact of seed production of scampi in brackish water pond in NICRA villages:

Intervention	Yield (nos/1000 m^2)	Cost of cultivation (₹ 1000 m^{-2})	Gross returns (₹ 1000 m^{-2})	Net returns (₹ 1000 m^{-2})	BC ratio
Mass seed production of scampi in brackish water pond	6,00,000	72,500	3,00,000	2,27,500	4.14

Scope for upscaling: This technology can be upscaled widely through the state fisheries department, PMMSY, NFDB and also by supplying them on subsidy. Local entrepreneurship can also be encouraged which can further contribute to upscaling.









Mass seed production of scampi in brackish water pond at North 24 Parganas

Rooftop rainwater harvesting for safe drinking water and aquaculture: A climate-resilient practice in the Sundarbans

Climate vulnerability: Salinity

Background: The Sundarbans, a vast flat, densely forested, and marshy islands interlaced with saline tidal estuaries and creeks, has challenges related to freshwater availability. Over time, many islands have been inhabited by converting mangrove forests into cultivable lands protected by embankments. However, access to potable water remains a major constraint. Groundwater, currently the only dependable source of safe drinking water, is depleting rapidly. The extractable freshwater aquifer now lies beyond 1200 feet, making groundwater extraction both costly and unsustainable.

Details of the technology: To address the shortage of potable water in the coastal villages of the Sundarbans, an innovative rooftop rainwater harvesting system was introduced. This system utilizes rainfall collected from roof catchments for drinking, cooking, and aquaculture purposes, particularly in Asian catfish (Clarias batrachus) hatcheries. This system is composed of a catchment area (the roof), the rainwater gutters to collect and transport the rainwater, the first flush device to discard the first few minutes of precipitation carrying the dusts deposited on the roof, a slow sand filter to remove the remaining suspended particles and silts present in rainwater and lastly, a storage tank of various capacity.

Performance and impact of technology: This system of water harvesting has dual advantage of providing water for household usage and also helps in Asian Catfish Hatchery. The harvested rainwater provided a reliable and safe source of drinking and cooking water throughout the monsoon months. It reduced the drudgery of women who previously walked long distances to fetch potable water, as water was now available conveniently at home. A 1000 L storage tank supplied drinking water for approximately three months post-monsoon, while occasional winter rains helps in extend availability of water. The harvested rainwater also benefitted rural youth engaged in Asian catfish hatchery operations in NICRA villages. Earlier, larval rearing was adversely affected by the poor quality of muddy pond water used during the rainy season. The rainwater met all water quality parameters, enabling higher hatching rates and improved larval survival. Each storage tank was refilled four times during the monsoon, supporting three successful breeding cycles of Asian catfish. This innovation also reduced dependency on groundwater, promoting sustainability and helped to realise a net benefit of ₹ 45,000 and a BC ratio of 4.0 (Table 35).

Table 35: Impact of rooftop rainwater harvesting through fish hatcheries

Intervention	Fish fry produced (no.)	Cost of establishment (₹)	Gross returns (₹)	Net returns (₹)	BC ratio
Fish hatcheries from rooftop rainwater harvesting	20,000	15,000	60,000	45,000	4.00

Scope for upscaling: Farmers can easily install such a system with the technical help from RAKVK experts. Roof top rainwater harvesting can ensure a sustainable source of potable water for each and every household of Sundarbans. Apart from drinking and cooking, it can also provide a scope for alternate income generation activities.



Various uses of potable water collected through rooftop rainwater harvesting including fish

Storm-resilient two-tier poultry housing in the Sundarbans: A climate-resilient housing model

Climate vulnerability: Cyclone

Background: Poultry is a vital livelihood source for rural households in the Sundarbans. However, frequent storms and cyclones often damage traditional poultry shelters, leading to high bird mortality and financial losses. Conventional structures typically accommodate only 10–15 birds they are overcrowded and unhygienic. The low floor height, often at ground level, results in waterlogging and muddy floors during the rainy season, causing high incidence of ecto- and endo-parasite infestations.

Details of technology: To address the challenges of storms and cyclones in Sunderbans, a storm-resistant two-tier poultry shelter was designed by RAKVK, Nimpith, and demonstrated in NICRA villages. A wooden structure of 6 ft × 4 ft × 7 ft which has two tiers, each accommodating 15 birds was made. This structure has a 1.5 ft ground clearance which prevents flooding during heavy rains. The side walls of the structure are made of 2-mesh GI net, and the roof is constructed with corrugated tin sheets, insulated internally with thermocol to reduce heat stress. Green shade-net curtains shield the birds from rain and help maintain comfortable temperatures during extreme weather. The entire unit is lightweight and portable, allowing easy relocation during emergencies such as inundation or when trees fall.

Performance and impact of technology: The improved shelters were demonstrated to over 50 farmers who previously used traditional housing. The new structure was storm-resistant, hygienic, and thermally comfortable, protecting birds from rain, predators (snakes, mongoose, dogs, foxes), and submergence. The improved ventilation and cleanliness reduced disease incidence, while roof insulation and curtains minimized heat and cold stress. Each unit now accommodates 30 birds, doubling farmer income (Table 36). Mortality and culling rates have declined, and body weight gain and egg production have improved. This design is a low-cost, climate-resilient innovation for coastal poultry farmers and the net returns increased by ₹ 9200 .

Table 36: Impact of the two-tier shelter model for backyard poultry

Intervention	Total birds/ unit	Space per bird (sq ft)	Eggs/ bird/ year	Economics per beneficiary per year		
				Gross cost (₹)	Net returns (₹)	BC ratio
Traditional system	15	1.0	159	6,050	6,700	2.11
Storm-resistant two-tier shelter	30	1.6	168	12,400	15,900	2.28

Scope for upscaling: The cost of a two-tier poultry unit is only ₹ 16000. Farmers can easily upgrade their poultry shed with this technology. However, this technology can further be scaled up

by support through other programmes of the state and central government or by initiative of other voluntary organizations.



Traditional poultry shelter



Storm resistance 2-tier poultry shelter



Storm resistance 2-tier poultry shelter with increased production

Vanaraja Poultry: A climate-resilient breed for rural livelihoods of South Andaman district of Andaman and Nicobar Islands

Climate vulnerability: Waterlogging

Background: Backyard poultry is a traditional and sustainable livelihood option for rural households. However, indigenous chicken breeds have low productivity, limiting income generation. To overcome this, improved dual-purpose breeds like Vanaraja have been introduced for enhanced meat and egg production with minimal inputs. Vanaraja was developed by ICAR-DPR, Hyderabad, to thrive under backyard rearing conditions, contributing to nutrition and livelihood security of rural families.

Details of technology: Vanaraja is a dual-purpose breed suitable for backyard rearing under scavenging conditions with minimal supplementation. The key features include 110-130 eggs per hen per year, The birds attain 1.0-1.2 kg live weight by 6 months under basic feeding. The bird has higher adaptability hence it performs well on household and scavenged feed resources. Further more, the Special traits of the birds were they have multi-coloured feather pattern providing camouflage against predators, The birds have high disease resistance, Low nutritional requirements, fast growth rate, they give brown eggs similar to local hens which are preferred in rural markets

Performance and impact of technology: Demonstrations were conducted to evaluate the performance of vanaraja birds in backyard systems. The introduction of vanaraja breed in backyard poultry systems enhances meat and egg production with minimal additional inputs, resulting in improved household income and nutritional security. Its high adaptability, disease resistance, and dual-purpose nature make it an ideal choice for livelihood improvement in rural areas (Table 37).

Table 37: Impact of introducing Vanaraja chicken breed in the backyard poultry farming

Technology adopted/ demonstrated	Production (kg year^{-1})	Selling price (₹ kg^{-1})	Gross returns (₹ ha^{-1})
Vanaraja with vaccination	76.8 kg	250	19,200
Vanaraja with vaccination	64.4 kg	250	16,100
Vanaraja with vaccination	44.1 kg	280	12,380

Scope for upscaling: The technology can be scaled up through state livestock missions, poultry development programmes, and integrated farming systems to improve rural livelihoods across similar agro-ecological zones.









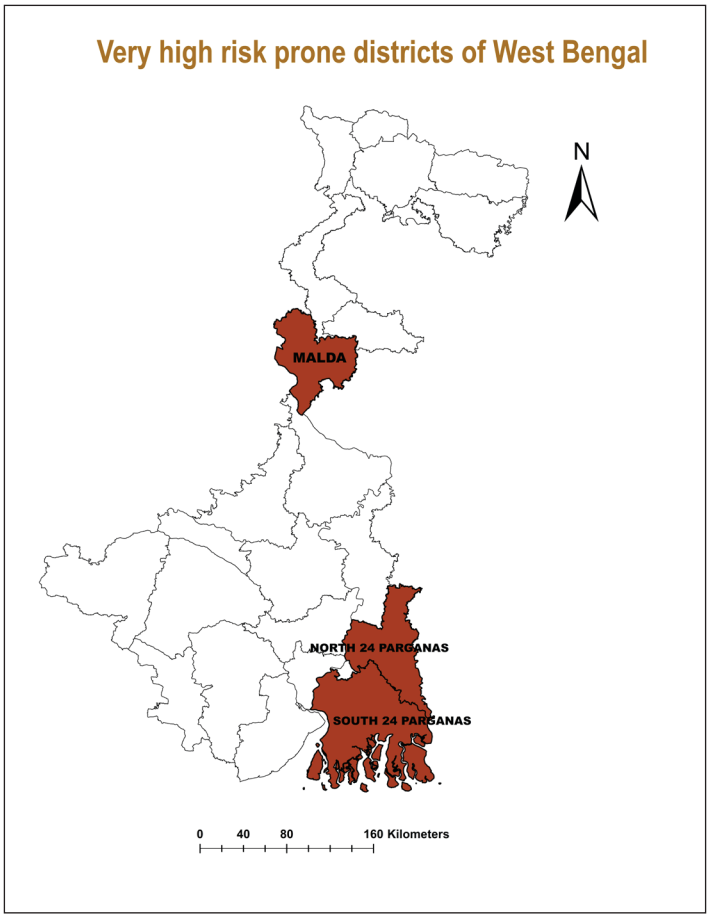


Introduction of Vanaraja chicken breed in the backyard poultry farming

3. Climate Resilient Technologies for risk prone districts of West Bengal and Andaman & Nicobar

Climate resilient technologies for risk prone districts of West Bengal

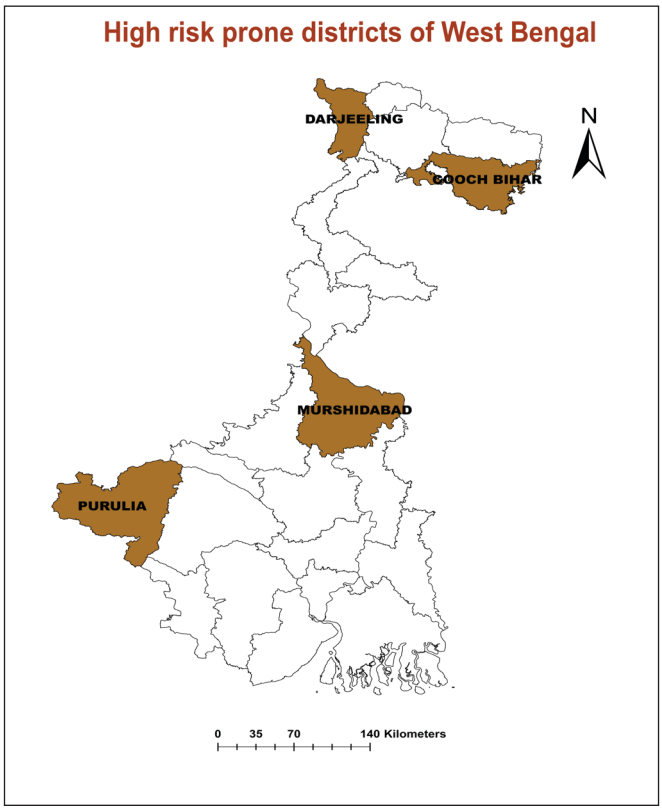
Districts of West Bengal can be broadly categorized into very high risk and high risk, based on proneness to climatic change and variability. Based on the on-farm experimentation being taken up as part of Technology Demonstration Component of NICRA and also other studies, technologies which can impart resilience to climate change and variability for various risk prone districts of West Bengal are indicated. The specific technologies for each of the farming situation in these districts depends on resource endowments, predominant production systems and the production objectives of the farmers. Promising resilient technologies for each of the risk prone categories for different districts of West Bengal are as follows.



Promising climate resilient technologies for very high-risk prone districts in West Bengal

1. Land shaping as a climate smart model for the Sundarbans
2. Vegetable production through land embankment (Ail) cultivation
3. Harvesting as a sustainable source of potable water for versatile use in rural Sundarbans
4. Mass seed production of scampi in brackish water pond
5. Floating rice seedbed - A climate resilient technology against shortfall of rain in North 24 Parganas.

6. Floating duck house - A climate resilient technology to combat natural calamity in Sundarban delta.
7. Supplementation of mineral mixture for enhancing productivity of livestocks.
8. Introduction of Super Napier grass as a green fodder at coastal village to alleviate animal stress and better production.
9. *In-situ* moisture conservation practices through zero tillage technology in wheat
10. Use of organic mulch in vegetables
11. Varietal improvement of sugarcane (Swapan and Birendra) cultivation in NICRA villages of Malda
12. Vegetables based multi-tier horticulture system
13. Low cost azolla cultivation as green fodder for milching cow and poultry birds as protein supplement.
14. Rearing of black bengal goat with low cost goatery house in flood prone areas
15. Multiple crop cultivation through broad bed cum trench system
16. Storm resistant two-tier shelter model for backyard poultry in Sundarbans



Promising climate resilient technologies for high risk prone districts of West Bengal

1. Cultivation of Dalley Chilli using poly-mulching
2. Supplementation of area specific mineral mixture for enhancing productivity of livestocks

3. Renovation of existing pond for harvesting, storing and recycling of rain water
4. Use of plastic mulch in bitter gourd production in trellis system during *kharif* season
5. Resource conservation through zero tillage in maize/wheat
6. *In-situ* moisture conservation through organic and poly mulching in vegetable crops
7. Submergence tolerant rice varieties to improve the socio-economic status of farmers
8. Income generation of women farmer through mushroom cultivation
9. Cultivation of maize using 4-row multi-crop planter
10. System of rice intensification for higher productivity and income
11. Income generation of rural women through milky mushroom cultivation
12. Millets cultivation in degraded uplands and drought prone areas
13. Cultivation of maize using 4-row multi-crop planter
14. Direct seeding of *kharif* rice
15. Accelerated jute retting using 'CRIJAF-SONA' & 'NINFET Saathi' followed by dip treatment in Vizol Polyquat for improving fiber quality
16. Nursery management of boro paddy to avoid cold injury and minimize use of irrigation water
17. Mulching for better resource utilization in okra production
18. Agri-silvi-pastoral system, animal husbandry – A IFS model to combat climate vulnerability
20. Intercropping with cowpea and berseem in hybrid napier in rotation – to mitigate green fodder crisis

Climate resilient technologies for South Andaman district of Andaman and Nicobar Islands

South Andaman District Andaman and Nicobar Islands is high risk prone, based on proneness to climatic change and variability. Based on the on-farm experimentation being taken up as part of TDC of NICRA, technologies which can impart resilience to climate change and variability are indicated, which depends on resource endowments, predominant production systems and the production objectives of the farmers. Promising resilient technologies for South Andaman district of Andaman and Nicobar Islands are as follows.

Promising climate resilient technologies for South Andaman district of Andaman and Nicobar Islands

1. Broad bed and furrow (BBF) technology

2. Use of bio-stimulants for abiotic stress management and yield enhancement in vegetable crops

3. Vanaraja chicken breed for backyard poultry farming









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