CENTER FOR ATMOSPHERIC AND CLIMATE SCIENCES

INDIAN INSTITUTE OF TECHNOLOGY MADRAS • सिद्धिर्भवति कर्मजा •

Progyan
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IndusInd Bank



Learning Landscape

Stories of Climate-smart Agriculture

Resilient farms build resilient futures



Foreword

This book matters because it brings together real, field-tested solutions that address some of the most pressing challenges in agriculture today-climate change, declining soil health, and livelihood insecurity. By showcasing climate-resilient agroforestry models, it bridges the gap between scientific knowledge and on-ground implementation, demonstrating how sustainable practices can enhance productivity, restore ecosystems, and secure farmer incomes. More than just a documentation, it highlights scalable and adaptable approaches that can be replicated across diverse regions, while giving voice to community-led innovations and success stories. Ultimately, it serves as both an inspiration and a practical guide for building resilient food systems and ensuring long-term environmental and economic sustainability.

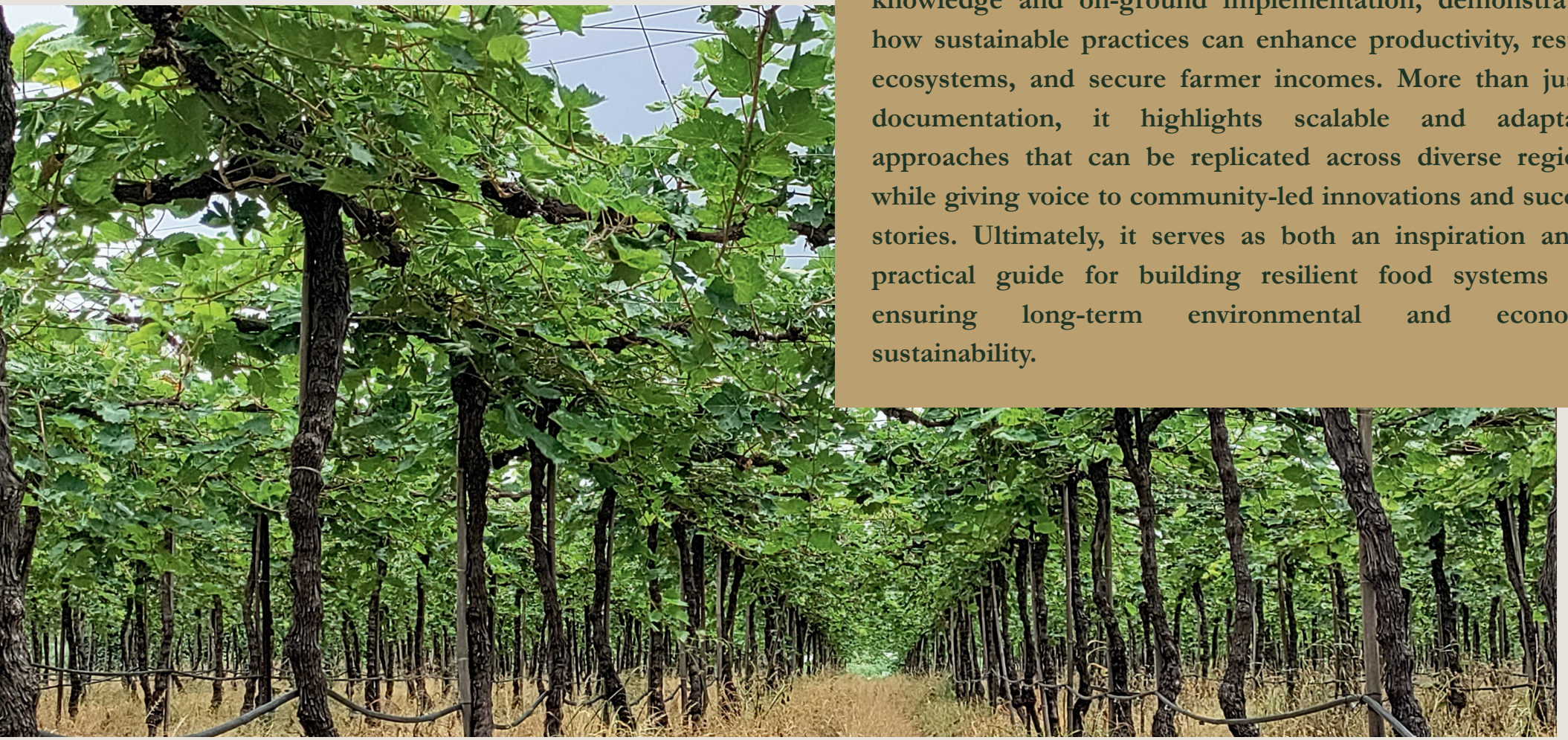




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About the initiative

Project overview

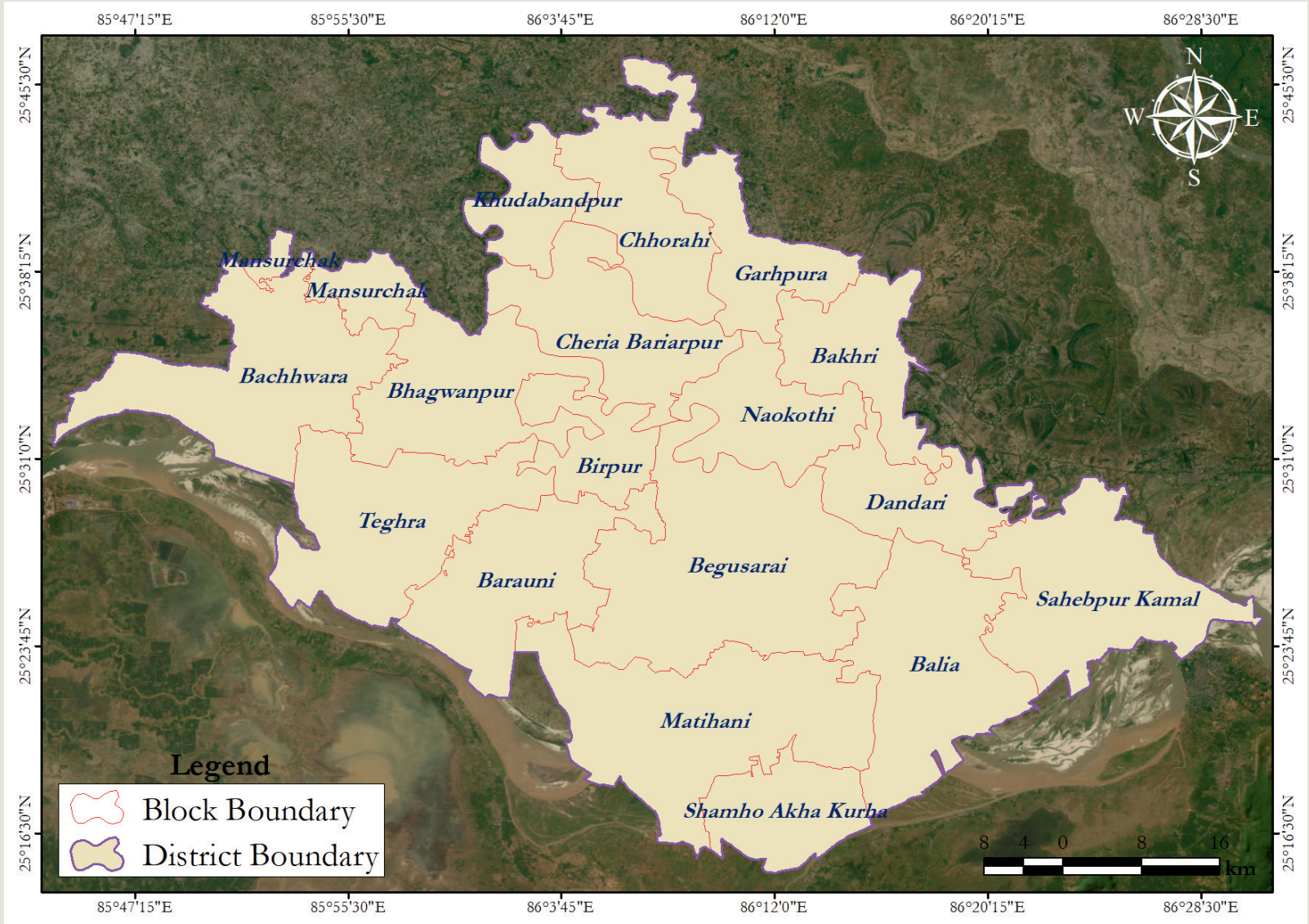
The project focuses on developing and demonstrating climate-resilient agroforestry models to enhance sustainable livelihoods among marginal farming communities in climate-vulnerable regions of Bihar (Begusarai) and Maharashtra (Dharashiv). By integrating trees, crops, and innovative practices such as float farming and no-tillage cultivation, the initiative aims to improve soil health, optimize water use, and strengthen resilience against climate variability. Through field-level pilots, capacity building, and stakeholder convergence, the project promotes diversified farming systems that increase productivity, ensure year-round income, and enhance food security. It also contributes to climate change mitigation through carbon sequestration while supporting community-driven, scalable solutions for long-term ecological and economic sustainability.



Geography

Begusarai in Bihar represents flood-prone, alluvial plains with high agricultural dependency, while Dharashiv in Maharashtra reflects drought-prone, semi-arid conditions-together capturing contrasting climate vulnerabilities addressed through resilient agroforestry models.





Location map of Begusarai, Bihar, India

Natural Resources

Water Resources
Irrigation

Land Bank
88% agricultural (Rice, Vegetables)

Fertile Soil
Wheat, Pulses, Rice & Millets

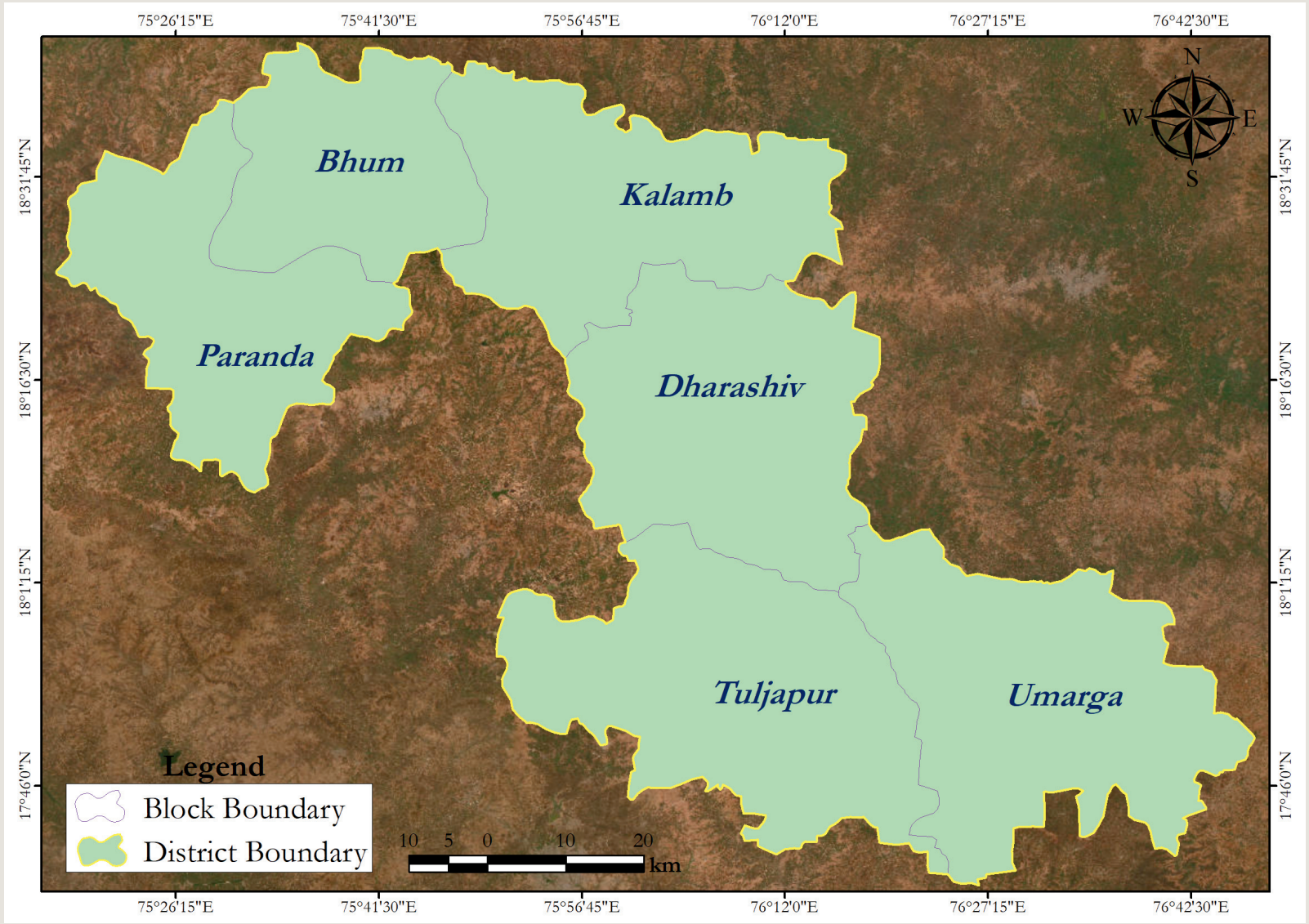
Livelihoods

Primary & Secondary
80% Agriculture (Rice, Vegetables)

Challenges

Waterlogging
Affecting agricultural production

Soil Degradation
Overuse of soil lead to reduced crop yields



Location map of Dharashiv, Maharashtra, India

Natural Resources

- **Land Bank** — *75% of total land bank*
- **Fertile Soil** — *Corn, Vegetables, Chilies, Wheat & Pulses*

Livelihoods

- **Primary** — *82% Agriculture*
- **Secondary** — *Dairy & Transport*

Challenges

- **Dependency on Groundwater**
- **Lack of Labour**
- **Lack of Climate-Resilient Technology**



Key Challenges

- Climate: Erratic rainfall, floods, and droughts
- Soil: Degradation, erosion, and declining fertility
- Livelihoods: Low productivity, income instability, and high risk

Approach

- Site-specific, need-based agroforestry interventions
- Aligned with local climate, soil, and farming systems
- Integrates trees, crops, and water management
- Optimizes resource use and ecosystem services
- Enhances resilience, productivity, and livelihoods



Climate resilient agriculture

What is it?

Climate-resilient agriculture is an approach that helps farming systems remain productive, ecologically stable, and economically viable under changing climate conditions. It includes crop diversification, soil and water management, risk reduction, and livelihood strengthening. In this initiative, it was demonstrated through agroforestry models, which integrate trees with crops in the same farming system to improve productivity and ecological stability, and float farming, which enables cultivation on floating beds in waterlogged conditions.



Why it matters

- Climate variability and extreme events increasingly affect crop productivity, soil condition, water availability, and the stability of farm-based livelihoods
- Resilient farming systems are needed to reduce exposure to production shocks, income disruption, and climate-related loss and damage
- Strengthening ecological functions and livelihood security is essential for sustaining agricultural productivity over time





Key Features of Implementation

Begusarai

- **Soil and land stability:** Keeping land under productive cover, improving soil structure, supporting carbon sequestration, reducing topsoil erosion, and limiting nutrient loss during heavy rainfall and runoff
- **Water-use efficiency:** Enabling flood-resilient production and converting inundated spaces into productive areas instead of periods of complete loss
- **Biodiversity and system resilience:** Increasing on-farm diversity, strengthening ecological balance, and reducing dependence on monocropping
- **Livelihoods:** Generating multiple outputs from crops, vegetables, and fish, improving income continuity, reducing market risk, and lowering loss and damage during flood periods





Dharashiv

- **Soil and moisture conservation:** Improving soil cover, organic matter, nutrient cycling, moisture retention, and carbon sequestration, while reducing land degradation
- **Water-use efficiency:** Reducing moisture stress and supporting production under variable rainfall conditions
- **Biodiversity and system resilience:** Strengthening agrobiodiversity to improve ecological resilience and reduce climate vulnerability
- **Livelihoods:** Supporting year-round income generation, improving household nutrition, reducing market risk through diversified outputs, and lowering climate-related loss and damage

Model 1:

Rooted diversity for resilient harvests - Mixed cropping of fruit plant with cereals



Key Features

- Integrates perennial fruit trees with annual cereals for diversified production
- Combines deep-rooted and shallow-rooted species within the same production system
- Maintains vegetative cover across crop layers and seasons
- Regulates field microclimate and moderates heat stress on intercrops

Potentiality

- Supports climate mitigation through carbon sequestration and reduced GHG emissions
- Enhances climate adaptation by improving resilience to drought and temperature stress
- Biological pest regulation by supporting natural enemies and reducing climate-induced crop stress
- Improves soil structure, infiltration, moisture retention, and erosion control, for water-use efficiency and flood adaptation
- Increases production stability and livelihood resilience through spatial and temporal crop diversification



Model 2:

Nourishing soils, sustaining livelihoods - Agro-horticulture Fruit plants with Pulses

Key Features

- Integrates perennial fruit trees with leguminous intercrops
- Incorporates biological nitrogen fixation into the production system
- Optimises resource use through complementary deep and shallow root systems
- Maintains a diversified and biologically active cropping arrangement

Potentiality

- Regenerates soil health by improving nitrogen availability and nutrient cycling and reducing synthetic fertiliser usage
- Enhances water-use efficiency under drought-prone conditions
- Climate mitigation through above- and below-ground carbon sequestration
- Supports agrobiodiversity and ecological stability
- Strengthens food security and livelihood stability through crop diversification





Model 3:

The miracle tree powering resilient fields - Agro-horticulture using Moringa with Cereals



Key Features

- Integrates moringa with cereals in a multifunctional climate-resilient system
- Combines a fast-growing perennial species with seasonal staples
- Generates on-farm biomass that can be returned to the soil
- Adds a nutritionally valuable tree component to the farming system
- Regulates microclimate, reducing thermal and moisture stress on crops
- Supports biodiversity, including pollinators and beneficial insects

Potentiality

- Strengthens drought adaptation through improved water-use efficiency
- Supports soil fertility regeneration through biomass recycling
- Promotes climate mitigation through rapid biomass accumulation and carbon storage
- Enhances ecological resilience through biodiversity-based pest regulation
- Improves household nutrition through nutrient-dense moringa-based products
- Diversifies farm income and strengthens livelihood resilience



Model 4:

Growing food on water during floods- Flood Resistant Float Farming

Key Features

- Uses floating rafts as cultivation platforms in waterlogged landscapes
- Employs growbags filled with organic substrate for crop production
- Integrates aquaculture beneath the floating cultivation units
- Efficiently uses water with minimal irrigation needs
- Reduces pressure on cultivable land

Potentiality

- Supports low-input organic production in flood-prone environments
- Reduces erosion-related loss of productive land
- Diversifies household income through combined crop and fish production
- Strengthens women's participation and local livelihood opportunities
- Supports carbon sequestration and biodiversity





Model 5:

Above-ground diversity with below-ground food security- Agroforestry Fruit plants with tubers

Key Features

- Integrates perennial fruit trees with underground food crops
- Utilises different rooting zones for complementary resource use
- Maintains productive land cover while reducing surface exposure
- Diversifies farm output through multi-layered cropping

Potentiality

- Enhances risk distribution through diversified harvests
- Reduces soil erosion, runoff, and nutrient loss
- Improves soil health through higher organic matter retention and root biomass
- Builds adaptive capacity under drought, erratic rainfall, and heat stress
- Supports ecological regulation, including pollination and pest suppression
- Improves calorie security through stable tuber production
- Strengthens resilience to extreme weather events and seasonal variability





Model 6:

Ancient wisdom for a changing climate - Climate resilient indigenous no tillage millet farming

Key Features

- Promotes climate-smart millet cultivation adapted to dryland ecologies
- Conserves soil moisture, structure, and fertility through no-tillage practice
- Retains crop residues and soil cover within the production system
- Operates as a low-input and climate-responsive farming model

Potentiality

- Improves soil health, moisture conservation, and rainfall-use efficiency
- Reduces soil erosion, land degradation, and soil carbon loss
- Lowers fuel use, operational costs, and GHG emissions
- Supports agrobiodiversity and ecosystem service retention
- Strengthens resilience to climatic variability in low-input farming landscapes
- Enhances food and nutritional security through climate-hardy crops





Model 7:

Harvests across seasons, income across time - Agro-horticulture of fruit plant with seasonal vegetables

Key Features

- Integrates perennial fruit plants with short-duration seasonal vegetables
- Combines long-gestation and short-cycle crops within the same field
- Maintains continuous productive use of land across seasons
- Increases cropping intensity through spatial and temporal integration
- Creates a diversified farm production system with complementary crop cycles

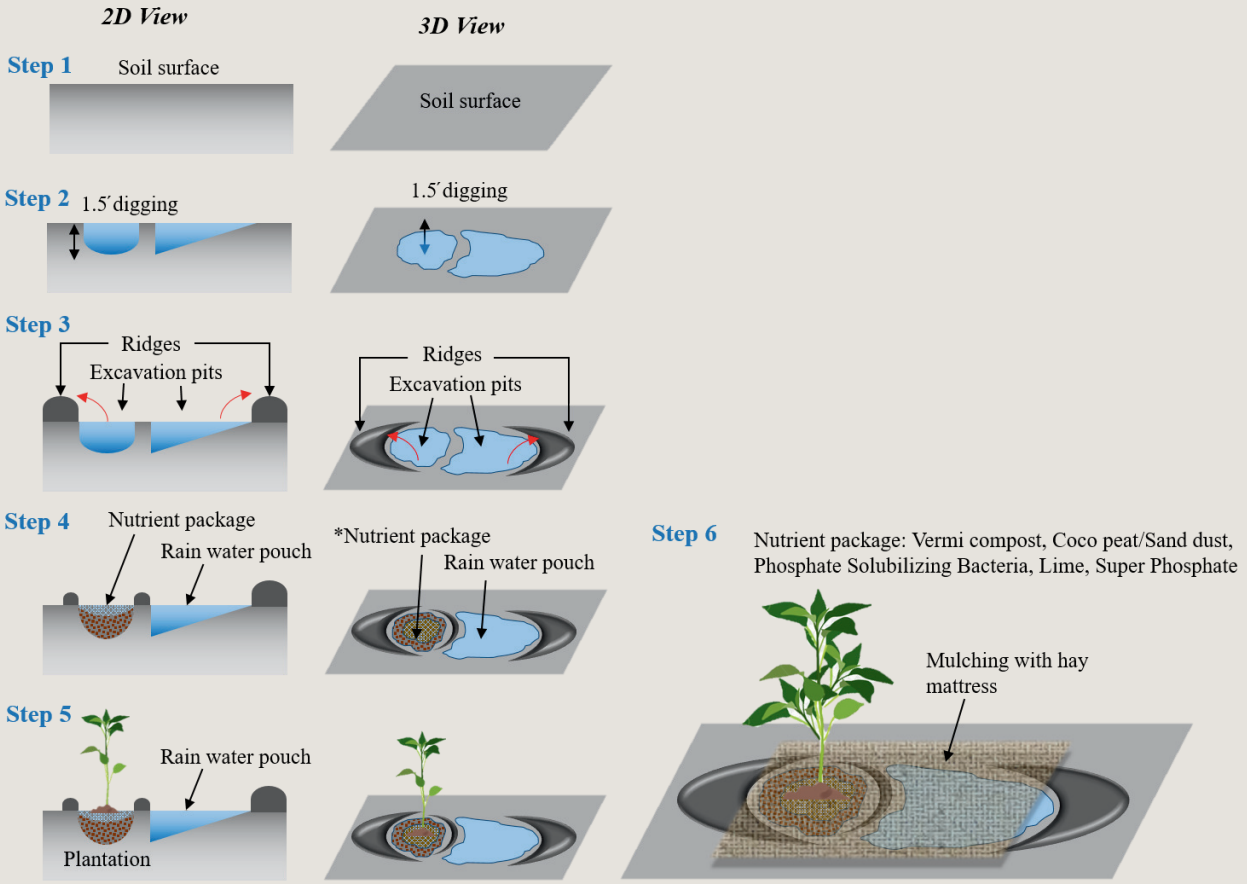
Potentiality

- Enhances agrobiodiversity and reduces monocrop dependency
- Improves soil health through continuous vegetative cover and organic inputs
- Promotes efficient water use and on-farm moisture conservation
- Supports climate mitigation through perennial biomass and carbon storage
- Reduces production risk through seasonal crop diversification





Water Resource Management for Drought-prone Areas (Dharashiv)



Model Approach: Agroforestry pouch planting

The pouch planting–based agroforestry model, integrated with rainwater harvesting, enhances resource-use efficiency by combining tree establishment, crop cultivation, and water conservation within a single system. It improves soil fertility, water retention, and biodiversity while promoting controlled root development and reducing interspecies competition. This integrated approach strengthens climate resilience through carbon sequestration, reduced soil erosion, and sustained productivity under variable climatic conditions.

Comparative Assessment of Model Performance in Dharashiv and Begusarai

Model Description	Location	Water Coefficient	Soil Health	Agro-Biodiversity	Yield Potential	Investment Demand	Labour Intensivity	Market Suitability	Climate Resilience	Carbon Leverage	Community Acceptability	TOTAL SCORE (-50 to +50)
		Graded from -10 to +10										
Perrenial Fruit & Cereals	Dharashiv	-4	5	0	7	-2	-4	2	4	3	7	18
	Begusarai	0	4	2	6	-4	-3	5	5	3	6	24
Perrenial Fruit & Legume	Dharashiv	-2	6	2	5	-3	-4	6	5	4	6	25
	Begusarai	2	5	0	5	-4	-4	4	5	4	6	23
Morynga & Seasonal Staples	Dharashiv	-2	3	4	7	-1	-3	6	6	5	8	33
	Begusarai	3	4	3	6	0	-3	5	5	4	8	35
Float Farming & Agroecology	Dharashiv	4	5	7	3	-4	-3	7	6	5	4	34
	Begusarai	4	5	7	4	-6	-5	8	9	5	6	37
Fruit plants & Tubers	Dharashiv	-3	-1	4	3	-2	-4	6	5	-2	5	11
	Begusarai	2	0	2	3	-3	-2	5	5	-2	5	15
No-tillage Millet	Dharashiv	-5	-2	7	3	-4	-2	6	6	-2	7	14
	Begusarai	0	-3	8	6	-3	-2	8	7	-2	5	24
Agro-horticulture	Dharashiv	-2	-2	6	7	-1	-3	6	3	-3	5	16
	Begusarai	-2	-3	7	8	-1	-2	6	2	-3	5	17

Monitoring and Evaluation



Dharashiv



Begusarai



















Advocacy









Community Sensitization



District Workshop

Multi-stakeholder District Workshop for Sensitization of Line Departments





National Workshop

Model Selection at ICAR-CAFRI


CACS
IndusInd Bank
National Workshop
Agroforestry in Climate Resilience, Sustainability and
12:16



National Workshop

Workshop on Climate Finance at KVK, Begusarai




National Workshop
Agroforestry and Carbon Credits: Prospects in Climate Finance





International Workshop

Climate-resilient Agriculture- Practice, Policy, and Prospects' at IITM, Chennai




MTII


IITM
Policy Meets Practice
Bridging the gap with farmer voices and research-driven coastal resilience
IndusInd Bank





Community Consultation & Final Validation




GUSARAI, BIHAR
Organized by
South As
Forum for Environment
& 9001:2015 Certified Organization]
llaboration with
Progya
r Research and Innovation



Voice from the ground



Mr. Sanjay Kumar

Kanwar Taal, Manjaur, Begusarai

"मैं इस खेती से पूरी तरह संतुष्ट हूं क्योंकि बाढ़ के महीनों में भी अच्छी फसल मिली" (I am completely satisfied with this farming because I got a good crop even during the flood months)



Mr. Jayshankar Kumar

Tetari, Begusarai

"मेरी भी यही राय है कि देशी फसलें जलवायु के प्रति अधिक लचीली होती हैं और मैं इस पर काम जारी रखूंगा।" (I also believe that native crops are more climate resilient and I will continue to work on this)

“मी या सरावाने खूप आनंदी आहे आणि पुढेही असेच चालू ठेवेन” (I am very happy with this practice and will continue to do so)

Mr. Kamlakar Kulkarni

Dautpur, Dharashiv



“कृषी वनीकरणाची थैली लागवड पद्धत योग्यरित्या कार्यरत आहे आणि पाण्याची सुरक्षितता सुनिश्चित आहे” (The bag planting method of agroforestry is working properly and water security is ensured)

Mr. Shivaji Giri

Dautpur, Dharashiv



Impacts

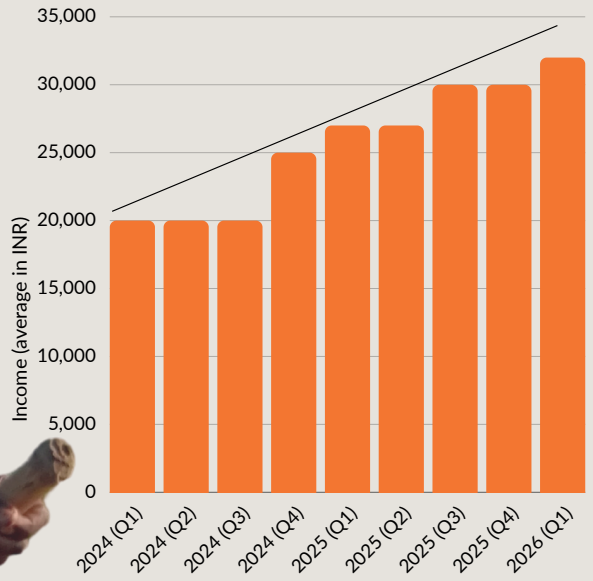


Farmers Reached: 11,500+ smallholder farmers benefited

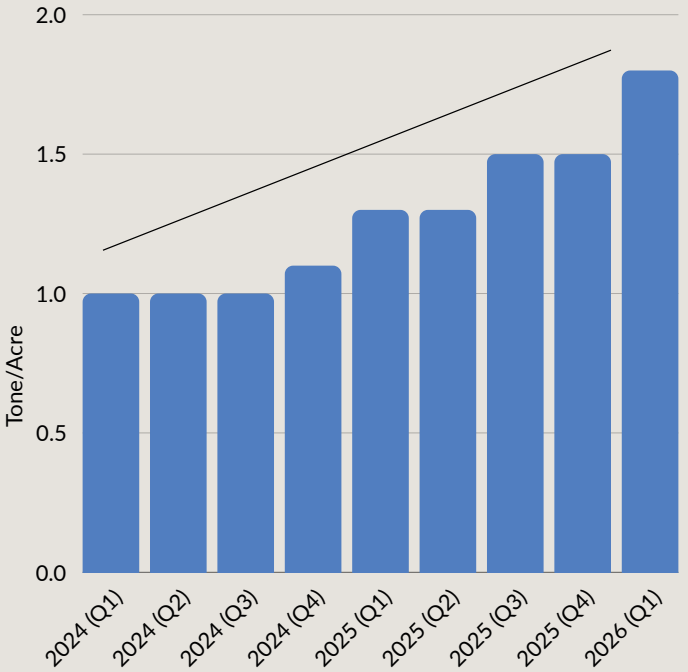


Area Covered: 80 acres under agroforestry interventions





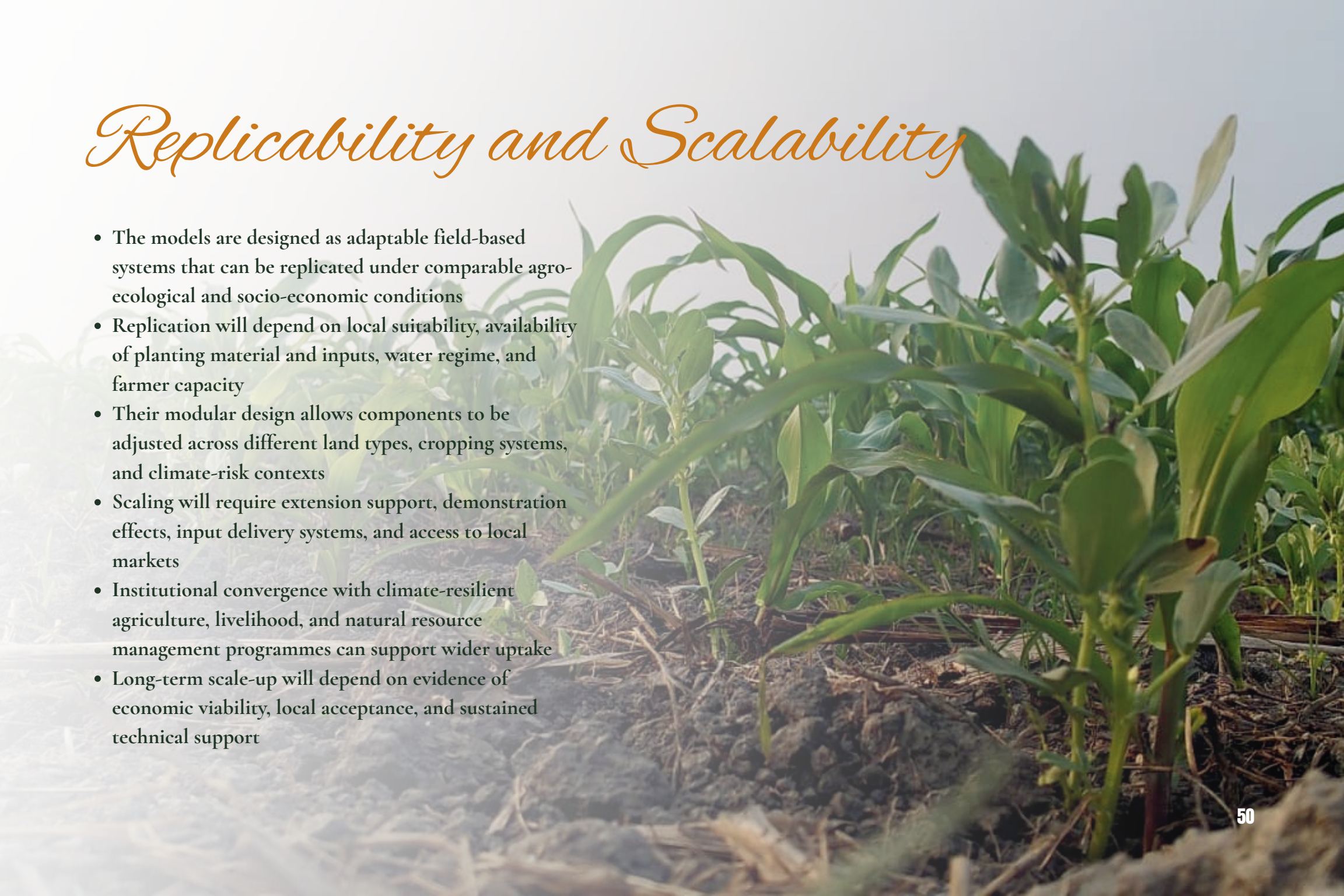
Income Improvement: 12 to 19% rise in annual farm income



Yield Increase: 25 % improvement across diversified cropping systems

Replicability and Scalability

- The models are designed as adaptable field-based systems that can be replicated under comparable agro-ecological and socio-economic conditions
- Replication will depend on local suitability, availability of planting material and inputs, water regime, and farmer capacity
- Their modular design allows components to be adjusted across different land types, cropping systems, and climate-risk contexts
- Scaling will require extension support, demonstration effects, input delivery systems, and access to local markets
- Institutional convergence with climate-resilient agriculture, livelihood, and natural resource management programmes can support wider uptake
- Long-term scale-up will depend on evidence of economic viability, local acceptance, and sustained technical support















Acknowledgements



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