

Promoting
Climate-Smart
Agriculture
for a Resilient Odisha

A White Paper

Promoting Climate-Smart Agriculture for a Resilient Odisha

A White Paper

Center for Study of Science, Technology and Policy (CSTEP)

June 2026

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A Decade of Progress

From relief to resilience

Reactive relief measures



Proactive evidence-based approach



Promoting climate-smart agriculture for a climate-resilient Odisha

Rising climate risks



Cyclones



Floods



Droughts



Heatwaves



148%

Increase in extreme precipitation events over recent decades



74%

of cultivated land is rainfed



93%

of farmers are smallholders

State-led initiatives

Scientific, data-driven policymaking



SAMRUDHI

Odisha Agricultural Policy (2020)



Shree Anna Abhiyan



Jalanidhi

Way forward



New convergence models



Decentralised planning



Coordination platforms

Executive Summary

Over the past decade, Odisha has made significant strides in embedding climate resilience into agricultural policy and planning, evolving from reactive relief measures to a proactive, evidence-based approach. Odisha's agriculture is at a critical crossroad. Intensifying climate disasters, including cyclones, floods, droughts, and heatwaves, have become more frequent and severe. For example, extreme precipitation events have risen by 148% over recent decades. To exacerbate conditions, nearly 74% of cultivated land is rainfed, and 93% of farmers are smallholders. These conditions make the state's agrarian economy extremely vulnerable. At the same time, state-led initiatives such as the SAMRUDHI Odisha Agricultural Policy (2020), the *Shree Anna Abhiyan*, and *Jalanidhi* have positioned Odisha as a pioneer in climate-resilient agriculture, demonstrating a commitment to scientific, data-driven policymaking. While these efforts have made strides towards resilience, emerging and localised gaps in climate-responsive planning, coordination, and gender inclusion persist and require continued attention.

For instance, irrigation infrastructure has expanded considerably with the advent of major irrigation projects. Yet utilisation remains uneven, with about half of kharif- and rabi-cropped areas currently irrigated and crops such as pulses and oilseeds largely rainfed. Moreover, only about half of all farmers were covered under crop insurance in 2023–2024, and just around 5% of land is under climate-resilient varieties. These aspects reflect opportunities rather than policy gaps, which the Government of Odisha is already addressing through new convergence models, decentralised planning, and coordination platforms such as the Climate Resilience Cell.

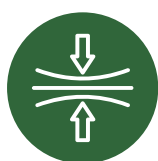
Against this backdrop, this white paper synthesises evidence across climate risk assessments, institutional delivery mechanisms, and policy architecture to examine how resilience is being built within Odisha's agriculture sector. It focuses on three interrelated dimensions:

- Water stress and methods to optimise irrigation systems,
- Resilience of farming systems through improved seed replacement, soil health management, and climate risk management, and
- Socio-economic and institutional mechanisms to enable inclusive adaptation outcomes, especially for women and tenant farmers.

To ensure that the benefits of resilience-building extend equitably across all farming communities, Odisha's next phase of climate action must focus on deepening the effectiveness and reach of ongoing programmes. This white paper, therefore, identifies four strategic interventions for climate-proofing Odisha's agriculture sector.



Enhancing water resilience through decentralised irrigation and conservation: This includes building on existing initiatives such as Farm Pond Plus, a dug well-based solar pump irrigation scheme under *Soura Jalanidhi*, alongside efforts to expand sustainable irrigation models that promote conjunctive use of surface and groundwater. In parallel, scaling up village-level water budgeting and micro-irrigation in drought-prone zones are complementary mechanisms to enhance water-use efficiency amid increasing climate variability.



Strengthening resilient cropping systems in climate-stressed regions: Decentralised, farmer-led systems (e.g., community seed banks) offer pathways to improve access to stress-tolerant varieties, while improved soil health management services can support more informed input use. Moreover, incentivising farmers to take up diversified, integrated farming systems aligned with Odisha's agroclimatic zones can further buffer risks and stabilise livelihoods.



Bridging agri-gaps through digital advisories and peer-led learning networks: The emerging role of this intervention enables adaptation at scale, thereby enhancing last-mile outreach. Agri-gaps can be bridged by strengthening access to climate advisories for crop management, decentralised post-harvest assets led by self-help groups and farmer producer organisations, and peer-to-peer extension.



Strengthening academic-farmer-state-market linkages through the Odisha Climate-Smart Agriculture Alliance (OCSAA): Improving coordination across government programmes, research institutions, financial systems, and farmer organisations is essential to close gaps in risk transfer, credit delivery, and knowledge flows. Expanding access to credit and insurance for tenants, smallholders, and women farmers through reforming the *Bhoomiheen* Agriculturist Loan and Resources Augmentation Model (BALARAM) and improving *Pradhan Mantri Fasal Bima Yojana* (PMFBY) uptake. This remains integral to reinforcing risk management-based decision-making within a broader, collaborative CSA ecosystem.

Together, these strategic focus areas can refine Odisha's demonstrated leadership in climate resilience. This aligns with the state's long-term, Viksit Odisha vision for promoting adaptive, inclusive, and climate-smart agricultural growth, which directly supports the state's KRUSHI 360 goals for 2047.



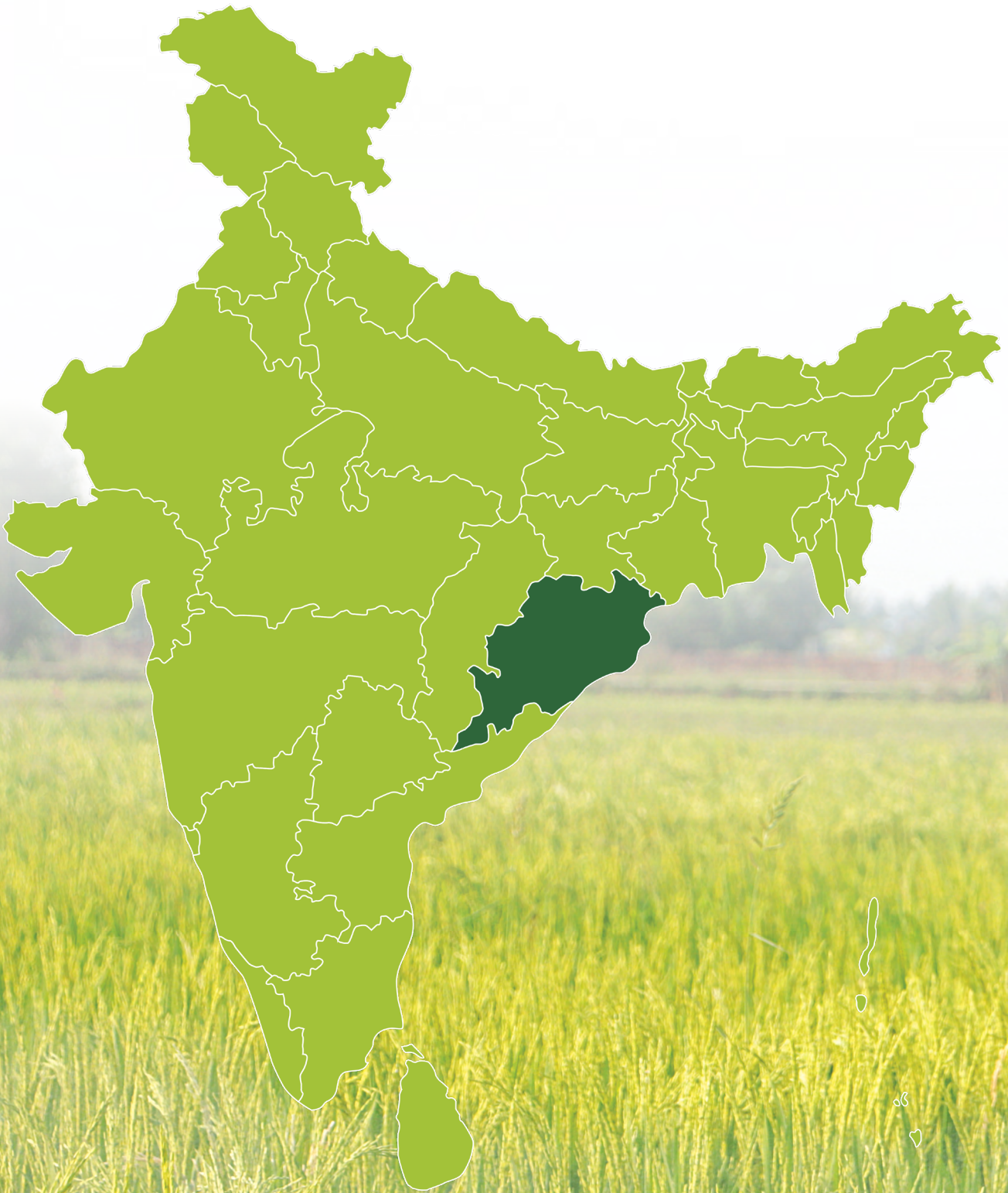


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1. Introduction

Odisha's agricultural system is shaped by a long history of structural vulnerability and adaptive transformation. During the British period, agricultural output remained low due to high land revenues; the consolidation of zamindari control; repeated climatic disasters, including floods (1856, 1897, 1920, and 1927) and droughts (1865 and 1897); and poorly maintained canal infrastructure that ultimately constrained productivity (Sarkar et al., 2022). Post-independence, agricultural stagnation persisted, with Odisha largely bypassing the Green Revolution despite the presence of fertile agroecological zones (Mishra, 2015). Today, Odisha remains one of India's leading rice producers, while also supporting diversified production systems spanning millets, pulses, oilseeds, horticulture, fisheries, and livestock (Department of Agriculture & Farmers' Empowerment [DA&FE], 2025). This reflects a transition from historically constrained agrarian growth to a diversified but climate-exposed agricultural economy.

This white paper forms part of the 'Promoting Climate-Smart Agriculture for a Climate-Resilient Odisha' initiative and serves as a foundational framing piece that establishes the need and a strategic direction for advancing climate-smart agriculture (CSA) planning in the state. Grounded in both secondary literature and field-based insights, this white paper highlights the intersecting challenges that drive agricultural vulnerability and exacerbate climate risks in Odisha. The purpose of this document is to identify actionable and scalable pathways for systematically mainstreaming climate adaptation into Odisha's agrarian systems.



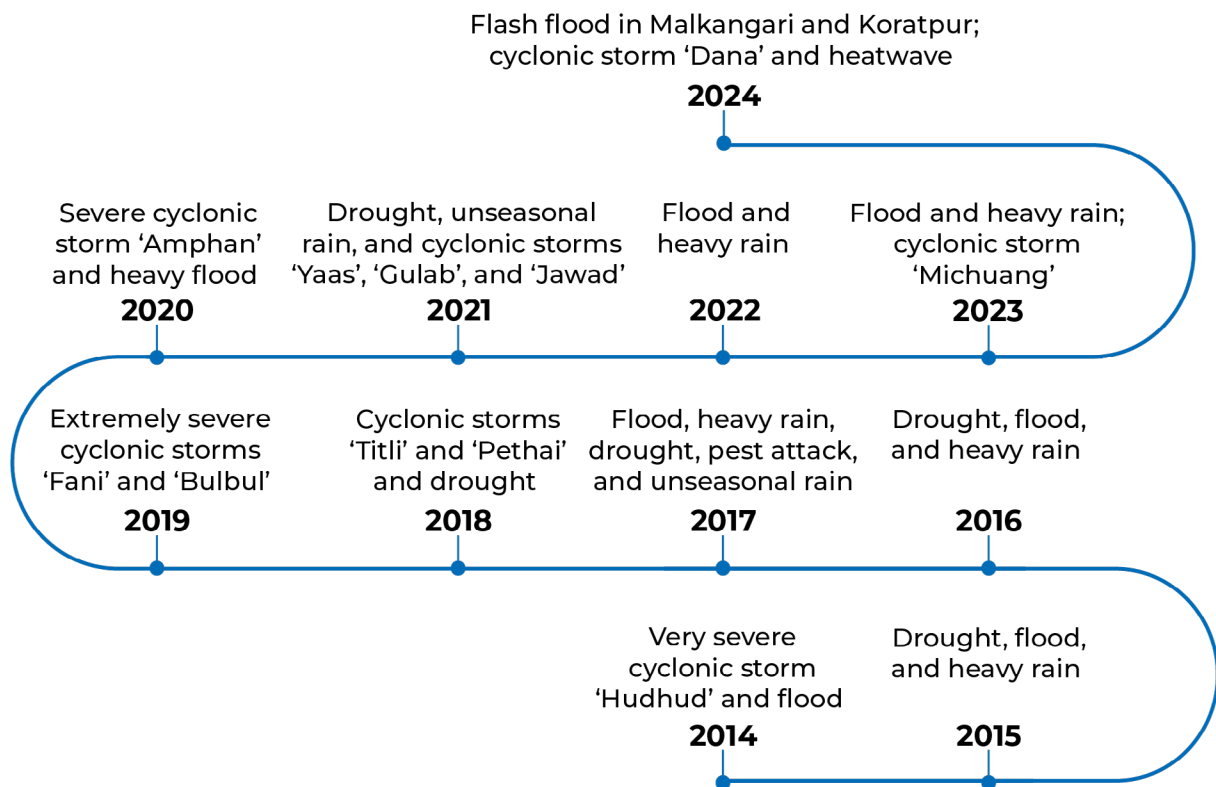
2. Need for Climate-Resilient Agriculture in Odisha

The state’s agricultural transition is being increasingly shaped by accelerating climate stressors that directly threaten productivity, livelihoods, and food security. The convergence of climate vagaries with ecological fragility and socio-economic vulnerability has transformed climate risk from an episodic disruption into a systemic development challenge for the agriculture sector. In this context, climate-resilient agriculture is a structural necessity for sustaining agricultural growth, stabilising rural livelihoods, and safeguarding long-term food systems. This urgency is clear from the evolving climatic patterns that now define the state’s risk landscape.

2.1. Evolving climatic patterns in Odisha

Over the past several decades, the state’s agriculture sector has become more susceptible to multiple climate hazards, such as droughts, floods, and cyclones (Sethi, 2025). Long-term climate data reveal a significant intensification of hydro-meteorological extremes, with extreme precipitation events increasing by 148%, from 23 events during 1961–1980 to 57 events during 2001–2019 (Mohapatra et al., 2021). As a coastal state, Odisha has also observed an increase in cyclonic activity, with districts such as Kendrapara, Ganjam, and Puri experiencing a threefold increase in cyclones and storm surges over the past 50 years. Extreme flood events have also increased sevenfold, affecting over 12.6 million people annually (Mohanty, 2020). The state’s geographical diversity makes it prone to these overlapping climate risks. Figure 1 shows the number of climate disasters that have impacted Odisha since 2014.

Figure 1: A decadal timeline of climatic hazards in Odisha (source: Special Relief Commissioner [SRC] reports, Odisha, 2014–2024)



2.2. Disaggregated impacts on the agriculture sector

Odisha's diverse geography mediates how climate hazards manifest across regions. As hazards become more frequent and intense due to climate change, the state is experiencing increasing water stress from erratic rainfall, saline water intrusion, and regional disparities in water access. For instance, the low-lying coastal districts of Kendrapara, Balasore, and Bhadrak are prone to waterlogging and floods due to their proximity to the Bay of Bengal (Center for Study of Science, Technology and Policy [CSTEP], 2025). Moreover, silt deposition from the Mahanadi and Brahmani river basins (which is essential to the sediment balance) contributes to persistent waterlogging and low agricultural productivity in 12 downstream districts (Odisha State Action Plan on Climate Change, 2022).

In contrast, Odisha's southern and western districts, particularly Nuapada, Balangir, Mayurbhanj, Malkangiri, Ganjam, Subarnapur, and Sundargarh, have been identified as drought-prone districts (CSTEP, 2025). These regions face frequent dry spells, soil moisture stress, and limited irrigation coverage, leading to crop failures. Moreover, districts such as Sundargarh and Mayurbhanj face overlapping risk from both heatwaves and droughts, while Balasore and Mayurbhanj are increasingly prone to the dual challenge of concurrent cyclonic storms and flooding (CSTEP, 2025). Major cyclonic storms such as *Phailin* (2013) and *Fani* (2019) have accelerated topsoil erosion and degraded nearly 35% of Odisha's arable land (Odisha State Disaster Management Authority, n.d.). Furthermore, 80% of the state's rice-growing communities have been affected by unpredictable monsoon patterns and prolonged dry spells, leading to soil moisture stress (Odisha State Action Plan on Climate Change, 2022). Alongside climatic stressors, Odisha's agriculture sector has been experiencing increased biodiversity loss and declining ecosystem health (DA&FE, 2024).

2.3. Agrarian structure and baseline vulnerability

The highly fragmented, smallholder-dominated production system that characterises Odisha's agriculture influences the sector's vulnerability to climate risks, underpinning the need for climate-resilient interventions. Nearly 75% of the state's total agricultural area is cultivated by small and marginal farmers, who make up over 93% of operational holdings (Odisha Economic Survey, 2022–2023). Furthermore, approximately 49% of Odisha's workforce is employed in agriculture (Directorate of Economics & Statistics, Government of Odisha [GoO], 2025). Therefore, disruptions in agricultural productivity caused by climate change significantly affect rural incomes, food security, and socio-economic stability.

The agriculture sector's susceptibility could also be attributed to two factors: (i) almost 74% of the state's cultivable land is under rainfed conditions, and (ii) a dominant reliance on water-intensive rice cultivation (Mishra, 2017; Odisha State Disaster Management Authority, 2025). These stressors, along with the existing vulnerabilities of the marginalised and women farmers and high dependence on rainfed monocropping systems, can exacerbate the impacts of extreme climate events with long-term implications for the sustainability of agriculture in the state.

2.4. Knowledge landscape and emerging directions

Odisha has articulated a clear policy direction towards strengthening climate resilience in agriculture through a combination of state-led programmes, institutional reforms, and technology-enabled service delivery. For instance, progressive state-led initiatives such as SAMRUDHI, *Shree Anna Abhiyan*, and targeted irrigation expansion supported by the Odisha Integrated Irrigation Project for Climate Resilient Agriculture (OIIPCRA) and *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) reflect strong commitments to resilience. However, a significant potential to strengthen ecosystem-based planning and systematically integrate locally tailored adaptation strategies remains untapped (Jogesh & Dubash, 2014).

This policy direction is supported by a growing body of literature examining the potential of CSA in Odisha and highlighting both opportunities and limitations. Sahoo et al. (2024), for instance, emphasise that while the adoption of CSA practices can positively influence a

farmer's well-being, access to new technologies remains uneven, particularly due to land fragmentation and insecure tenure rights. Das and Nayak (2024) have drawn on National Innovations in Climate Resilient Agriculture (NICRA) data and explained how adoption patterns of CSA practices vary across coastal and inland districts and are shaped by localised climate risks and institutional delivery mechanisms. Several state-led initiatives, such as *Ama Krushi* (now *Krushi Samruddhi*), and tools developed by organisations such as Niruthi are already enhancing farmers' access to timely, localised agro-advisories. However, evidence connecting advisory services to actual behaviour change or measurable improvements in resilience outcomes needs to be documented.



3. Understanding Constraints and Conditions for Promoting Climate-Resilient Agriculture in Odisha

This section outlines the key challenges influencing the pace and effectiveness of climate-resilient agriculture in Odisha. Odisha's farming communities and agricultural systems face deep-rooted vulnerabilities shaped by the state's biophysical, infrastructural, and institutional limitations.

The hinterland and marginalised farmers in the state continue to face constraints related to mechanisation, irrigation coverage, cropping intensity, and crop diversification (CSTEP, 2025). Further, small landholdings critically constrain adaptive capacity, as most of these holdings are rainfed and monocropped, in addition to having limited access to enabling services such as crop insurance, soil health cards (SHCs), or agronomic advisories (CSTEP, 2025).

Rather than isolated gaps, these challenges reflect interacting climatic, structural, and institutional factors that shape farmers' exposure to risk and their ability to respond. Understanding these dynamics is essential for strengthening ongoing policy and programme implementation. The following subsections examine these constraints in greater detail, focusing on water stress, farming system resilience, and the institutional and service delivery factors that shape adaptation outcomes.

3.1. Water stress and irrigation efficiency

Agriculture in Odisha is largely dependent on rainfall. This makes the crops highly vulnerable to fluctuations in monsoon rainfall, particularly those grown during the kharif season. For example, an empirical study in the state estimates that a minor deviation (as low as 1%) in rainfall is associated with a decline of approximately 0.48% in green gram yields (per hectare [ha]) relative to the long-term average (Jena et al., 2025).

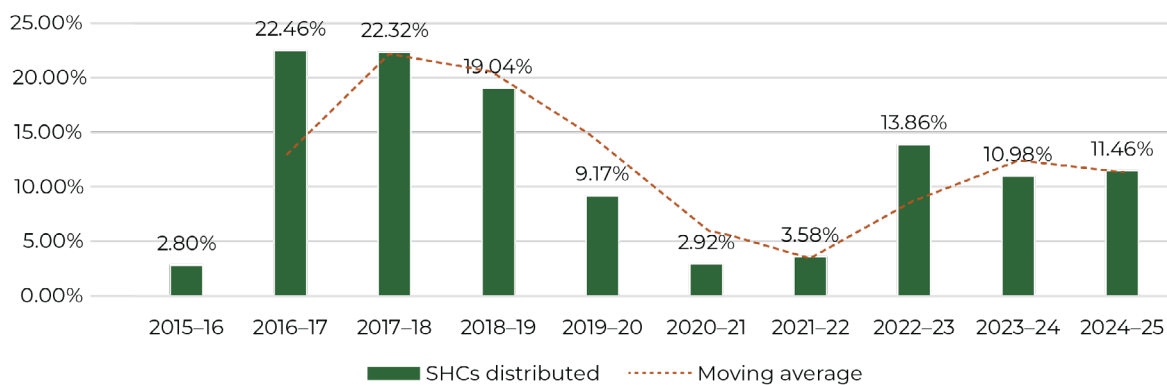
Spatial disparities in irrigation access also pose a major challenge for the agriculture sector. To begin with, coastal districts such as Kendrapara and Puri benefit from extensive canal networks linked to the Mahanadi delta, which irrigate over 75% of farmland. In contrast, western regions such as Sambalpur and Kalahandi depend on groundwater (accessed through bore wells and lift irrigation; Indiastat, 2024). Despite this reliance, according to the Central Ground Water Board (CGWB; 2023), the state's recorded groundwater utilisation rate was 46.3% in 2023 (i.e., utilisation of less than half of the extractable groundwater at the state level), which could be attributed to challenging terrain and cultural dependence on community surface water bodies for irrigation. However, the same report notes a slight increase (about 2.08%) in groundwater extraction from 2022 to 2023 (CGWB, 2023). If this trend continues, along with the recurring storm surges, the potential for saline water intrusion can ultimately increase and further compound water stress. Salinity intrusion has already degraded large tracts of coastal farmland, highlighting the urgent need for integrated groundwater and soil salinity management to help sustain agricultural productivity (Das et al., 2020).

3.2. Soil quality and land health under climate stress

Beyond water availability, soil quality constitutes a critical but often under-acknowledged constraint shaping agricultural vulnerability in Odisha. The soil health mapping by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT; 2020), based on the analysis of over 40,200 soil samples across all districts in the state, reveals widespread micronutrient deficiencies (80% boron, 42% zinc, 51% sulphur, 28% magnesium, and 43% carbon) and high spatial variability in nutrient status across agroclimatic zones. These limitations are compounded by nearly 126.8 lakh ha of acidic soils, marked by low organic carbon and reduced nutrient availability (Mishra et al., 2024). Under intensifying climatic stressors such as cyclonic flooding and storm surges (as outlined in Section 2), these soil constraints are exacerbated through accelerated nutrient leaching, topsoil erosion, and salinity ingress, deepening agricultural vulnerability.

In Odisha, the distribution of SHCs—a crucial entry point for improving input use and soil management—has fluctuated over the past several years. Notably, coverage dipped to 2.92% of farmers in 2020–2021, compared with the earlier peak of 22.46% in 2016–2017. Recent years, however, show a steady upward trend (Figure 2). Strengthening these foundational services presents an opportunity to further enhance the effectiveness of agriculture extension in the state and ensure timely soil advisories.

Figure 2: Trends in the distribution of SHCs in Odisha (DA&FE, 2022)



3.3. Gender dimensions and grounded realities for adaptation

A survey of self-help groups (SHGs) and women-led farmer producer organisations (FPOs) in Kanas and Pipili blocks of Puri district revealed how climate risks often arrive in rapid succession, that is, heavy rainfall followed by extreme heat, post-cyclonic soil salinity, delayed sowing, and a resulting loss of income (field observations by CSTEP). In response, some farmers reported abandoning kharif paddy altogether and shifting to rabi paddy, pulses, sesame, or integrated fish-paddy systems. Others in the Mahura Gram Panchayat, in the Satyabadi block of the Puri district, reported that heatwaves have shortened the shelf life of produce and made agricultural work more challenging, especially for women, who are more exposed to extreme daytime temperatures (field observations by CSTEP).

These inequitable impacts of climate shocks are partly a consequence of the disaggregated agricultural activities, where women’s participation in agricultural labour (often involving outdoor exposure and physically demanding tasks) increased by 37% between 2019 and 2024, while male labour participation decreased by 27% during the same time period (Odisha Economic Survey, 2024-25). Thus, there is a need for more gender-disaggregated data to better capture the roles of women in agricultural activities, which has led to the formation of a Gender Responsive Cell (GRC) that aims to address this gap through its Inclusive Agriculture Transformation indicators (Padhee et al., 2025).

Figure 3: Women farmer SHG being interviewed in Mahura Gram Panchayat



3.4. Extension, advisories, and last-mile delivery

A study by Das et al. (2024) found that the adoption of CSA practices in Odisha was strongly influenced by access to localised extension services and the timely availability of inputs. The study highlights persistent institutional capacity gaps, which are further compounded by limited access to financial and information support systems. For instance, factors such as inadequate access to credit, insurance, seeds of resilient crop varieties, and soil health inputs such as micronutrients, biofertilisers, and compost, continue to hinder adaptation efforts.

3.4.1. Strengthening seed distribution systems

Improved seeds can increase crop yields by 15%–20% (Singh et al., 2016). However, the seed replacement rates (SRRs)¹ vary significantly and are below ideal levels for several key crops in Odisha. For instance, while paddy has an SRR of 31.23% (meeting the 20%–30% ideal for self-pollinated crops), crops such as pigeon pea (*arhar*; 3.45%) and groundnut (7.55%) have very low SRRs, according to Odisha Agricultural Statistics, 2023-24. This suggests that a large proportion of farmers in the state may not be fully accessing improved, climate-resilient, or high-yielding varieties. Research by Jayara and Pandey (2017) indicates that factors such as outreach, the pace of integrating new varieties into formal seed supply chains, pricing structures, and farmer awareness on the benefits of certified seeds influence improvements in SRRs. This underscores the importance of investing in both supply systems and farmer-facing support to improve SRRs. Without reliable last-mile seed delivery and farmer-facing support to improve awareness, trust, and timely access to suitable varieties, improvements in varietal development are unlikely to translate into on-the-ground resilience gains.

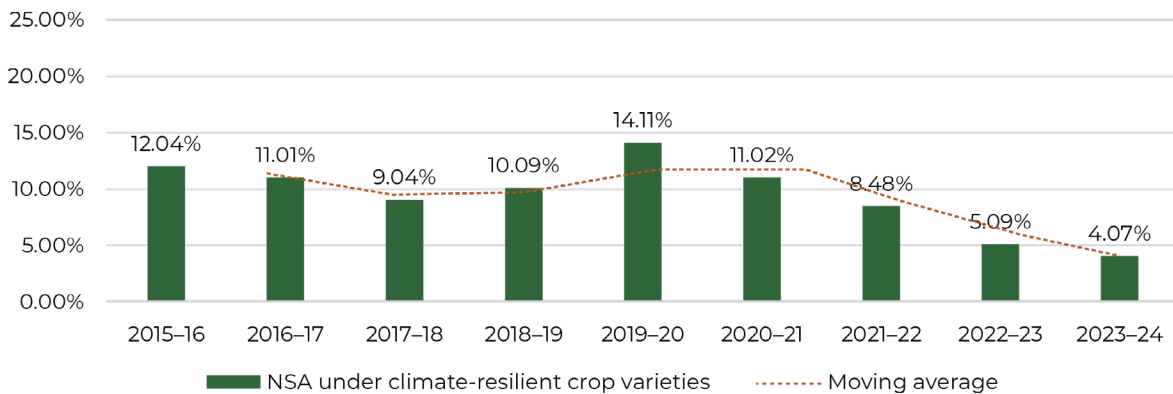
¹ SRR refers to the proportion of crop area sown using new, certified, or improved seeds rather than seeds saved from previous harvests.

Box 1: Stress-tolerant varieties (STVs) as a resilience buffer

Recurrent droughts and cyclonic rainfall continue to cause substantial crop damage in Odisha, with historical data highlighting the scale of these impacts. For instance, 3,24,590 ha were affected by drought in 2018–19, and 3,94,916 ha were damaged by cyclonic rainfall from Cyclone *Jawad* in 2021–22 (official estimates for losses from Cyclone *Motha* are awaited; Odisha Agriculture Statistics, 2023–24).

In this context, the government record indicates that 4.07% of the net sown area in 2023–2024 was under climate-resilient crop varieties. However, it is important to note that many more farmers may have adopted the STVs of crops, though this broader adoption (primarily through private players) is not yet systematically captured in existing data sets (Figure 4). Moreover, during the same year, 49.2% of the farmers were covered by some farm insurance scheme (DA&FE, 2024). The existing adoption rates of STVs, combined with widely used risk coverage mechanisms such as crop insurance, reveal noteworthy opportunities to enhance the state’s capacity to buffer farmers against climate-related risks.

Figure 4: Percentage of net sown area under climate-resilient crop varieties (NSA, net sown area; DA&FE, 2024)



3.4.2. Translating climate advisories into farming decisions

Adoption of digital climate services in Odisha remains uneven; however, this points to an immense potential. An ICRISAT study in Rayagada and Gajapati found that while 82% of farmers accessed weather advisories, uptake varied, i.e., 67% used them for decisions on sowing, but only 24% for irrigation decisions. The same study noted that farmers often relied on traditional knowledge, with low confidence in seasonal forecasts for decisions such as crop selection (Kumar et al., 2024). This suggests that while there is confidence in weather advisories for activities such as sowing and harvesting, an advisory system that provides reliable crop selection guidance based on local conditions may be required, along with crop management practices during different growing periods.

As a response, a dynamic Krushi Samruddhi agro-advisory service has been incorporated into the Krushak Odisha database, with an average uptake rate of approximately 40% (Samagra, 2025). However, the challenge now is to align the provision of information with on-the-ground capacity to respond, which could lead to focused and efficient uptake of such advisories. Moreover, a regular monitoring and evaluation of the utility, application, and impact of such advisories is strongly recommended.

4. Policy Responses: Progress and Opportunities

The aforementioned multi-faceted challenges (Section 3) highlight the opportunity to balance the scales at both ends: aligning relief-oriented efforts with an integrated, anticipatory resilience planning that is precautionary, preventive, and perseverance-based. This line of thinking is already evident in the state's progressive schemes; however, incorporating climate risk and gender-responsive approaches requires further institutional strengthening. This section outlines the state's major initiatives and provides a brief overview of their design, implementation, and potential opportunities for greater integration of CSA principles into programme frameworks and delivery mechanisms.

4.1. Strengthening financial resilience through risk protection and credit access

Financial risk protection and access to institutional credit form a critical pillar of climate resilience in agriculture, particularly in a state where climate shocks frequently translate into income losses and debt stress. Odisha has operationalised a combination of insurance and credit instruments to buffer farmers against climate-induced risks. Together, these schemes represent a shift from purely relief-oriented responses towards anticipatory financial resilience, though crucial implementation constraints persist. Subsequent subsections deep-dive into the three major state- and national-led interventions that Odisha has been leveraging.

4.1.1. Crop insurance under the *Pradhan Mantri Fasal Bima Yojana* (PMFBY)

This scheme provides insurance coverage for crop losses from natural calamities. In 2023–2024, PMFBY insured 23.96 lakh farmers across 16.35 lakh ha of agricultural land, with the sum insured amounting to INR 12,248 crore. This reflects the scheme's wide-scale reach and essential role in the state's risk management framework (Odisha Agriculture Statistics, 2023-24).

Despite this scale, farmers have reported delays in payout and dissatisfaction with grievance redressal. For instance, state-specific insights from Majumder (2021) point to essential procedural bottlenecks in the implementation of PMFBY, such as delays in crop-cutting experiments, low awareness of claim protocols, and weak grievance redressal mechanisms.

4.1.2. Weather-indexed insurance through the Restructured Weather-Based Crop Insurance Scheme (RWBCIS)

This scheme functions alongside PMFBY to compensate for weather-driven losses. Unlike traditional yield-based insurance, payouts under RWBCIS are based on weather triggers that are defined in crop-specific term sheets, thereby reducing the need for post-disaster loss assessments. The scheme's area-based approach also means that unless weather deviations cross the predefined thresholds at notified stations, localised damages may not always be eligible for payouts (Ministry of Agriculture & Farmers Welfare [MoA&FW], 2019). Therefore, greater uptake of these schemes necessitates strengthening farmer awareness and improving access to timely and reliable weather data, particularly given that the current coverage of automatic weather stations remains limited (MoA&FW, 2019).

4.1.3. Credit access for tenant and landless farmers through the *Bhoomihina* Agriculturist Loan and Resources Augmentation Model (BALARAM)

A state initiative launched in 2020, BALARAM explicitly seeks to target farmers cultivating leased-in land. Such leased-in operational holdings account for 18.6% of the total operational holdings in the state and represent a portion of the farming population that has traditionally been underserved by formal credit systems due to the absence of land ownership records. To improve the credit-worthiness of such farmers or sharecroppers, the scheme organises them into joint liability groups (JLGs). This also enables sharecroppers' access to institutional finance via primary agricultural credit societies (PACs) and other commercial banks (DA&FE, 2020). As of December 2023, over 56,000 JLGs had been formed, with 12,394 sharecroppers financed and INR 98 crore disbursed. Furthermore, INR 212 crore in kharif loans and INR 16.27 crore in financial support to 579 women SHGs were facilitated by mid-2023 (The New Indian Express, 2023; Odisha Economic Survey, 2024-25). The SAFAL (Simplified Application for Agricultural Loans) online portal has also streamlined credit applications for farmers and agri-entrepreneurs across the state.

Despite these achievements, BALARAM's implementation has encountered several hurdles (The New Indian Express, 2023). To begin with, a greater focus on addressing staff shortages is imperative to improve field outreach (especially from the village to the district level) and JLG mobilisation. Moreover, bank reluctance, a plausible consequence of outstanding loan defaults, leaves many JLGs ineligible for fresh loans. This, in turn, disincentivises *Krushak Sathis*, whose incentives depend on successful loan facilitation of the eligible groups, thereby weakening their motivation to mobilise and support new groups.

4.1.4. Enabling interventions that reinforce financial resilience

Krushak Assistance for Livelihood and Income Augmentation is another novel scheme in the state that provides direct income and input assistance to small and marginal farmers. This financial assistance helps farmers buffer climate shocks and could potentially enable them to adopt CSA practices.

Taken together, all these instruments illustrate Odisha's multi-layered approach to financial resilience, combining risk transfer and credit access. However, the discussed barriers under these schemes point to scope for stronger inter-departmental coordination and field-level capacity, as well as for improved credit flow mechanisms, to leverage the scheme's full potential.

4.2. Climate-proofing Odisha's irrigation strategy

Odisha has made significant progress in expanding irrigation infrastructure through initiatives such as *Jalanidhi* and state and centrally sponsored schemes. This reflects the sustained public investment in strengthening agricultural water security (see Box 2 for utilisation patterns and crop-wise irrigation coverage). Moreover, PMKSY focuses on enhancing water-use efficiency through micro-irrigation and promoting integrated farming systems (including crop-livestock-fish models) that are known to enhance livelihood resilience.

Odisha has also initiated decentralised, climate-resilient water management solutions. Check dams, community recharge systems, and rooftop water harvesting structures have been constructed under the *Jal Shakti Abhiyan* scheme, restoring 5,600 ha of saline-affected land and raising groundwater tables by 0.8–1.2 metres across 22 blocks (JSA Progress Report, 2023). Similarly, in Balasore, the use of decentralised ponds reduced soil salinity by 18% and increased paddy yields by 1.2 tonne/ha (DA&FE, 2022). Moreover, 12,000 rainwater harvesting structures have been constructed across 2,035 urban wards under the *Mukhya Mantri Karma Tatpara Abhiyan* (MUKTA) to improve groundwater recharge and water availability for peri-urban and drought-prone agricultural zones (UNICEF, 2021; Behal & Ram, 2021).

Building on these decentralised efforts, OIIPCRA (2021–25) represents a more integrated approach to strengthening irrigation access and resilience in rainfed areas. According to the World Bank Results Data Sheet (2024), OIIPCRA had planned to support about 72,805 ha of rainfed land and provide new irrigation or drainage services to approximately 24,833 ha of farmland. The project further supports these efforts by introducing climate-resilient pulse crops, promoting water harvesting, and strengthening farmer collectives and FPOs.

Box 2: Irrigation potential versus utilisation patterns

As of 2023–2024, the total irrigation potential created was 42.22 lakh ha for kharif and 16.26 lakh ha for rabi (Odisha Agriculture Statistics, 2023–24). At the same time, the actual utilisation was well below the potential created, reflecting, in part, continued dependence on monsoon rainfall and long-standing cultivation practices. Only 47.85% of the kharif-cropped area and 55.84% of the rabi-cropped area were irrigated in 2023–2024. While crops such as rice, sugarcane, and vegetables have relatively higher irrigation coverage, pulses (20.64% kharif; 26.70% rabi) and oilseeds (20.76% kharif; 50.18% rabi) remain predominantly rainfed. This cropping and irrigation pattern reflects planned allocation, as pulses and oilseeds are traditionally cultivated in rainfed, low-input requirement systems, while water-intensive crops are irrigated. Yet, under a changing climate, reliance on uncertain rainfall signals vulnerability, highlighting the need for provisioning measures such as supplemental irrigation and water-use efficient interventions.

4.3. Making farming systems climate-smart and adaptive

Odisha has launched a suite of policies to enhance the climate resilience of farming systems, particularly in rainfed, fragile, and tribal-dominated agroecosystems that are increasingly exposed to drought, erratic rainfall, and soil degradation.

The state agriculture policy, i.e., SAMRUDHI (2020), promotes sustainable intensification by encouraging balanced fertilisation, the adoption of climate-resilient crop varieties, ecosystem-based land-use planning, and the creation of contingency seed reserves. One of its key features is the introduction of dynamic seed-rolling plans that align seed supply with crop- and region-specific needs across seasons. These plans target improved SRRs, including 33% for paddy and 50% for cross-pollinated crops. Moreover, they aim to increase varietal replacement rates by replacing old varieties with hybrid, high-yielding, and better-performing indigenous varieties. The push towards replacement, unless locally validated, can pose a risk of maladaptation and biodiversity loss in fragile, tribal regions.

In addition to the state-led initiatives, several national-level policies with state-level applications also contribute to strengthening adaptive capacity in Odisha.

- i. The National Mission for Sustainable Agriculture (NMSA) is a holistic initiative with two major components that support the strengthening of adaptive capacity in Odisha.
 - (a) Rainfed Area Development (RAD) follows an area-based, integrated farming approach that not only enhances water-use efficiency but also soil health and crop diversification.
 - (b) Natural Resource Management (NRM) interventions, including dug wells and farm ponds, have provided life-saving irrigation to rainfed farmers. In one example, rabi green gram cultivation on ~133 ha of water-scarce areas was enabled through efforts under NRM, thereby benefiting 17,547 farmers since inception (CIFOR-ICRAF, 2023).

- ii. The *Paramparagat Krishi Vikas Yojana* (PKVY) promotes cluster-based organic farming under NMSA. In Odisha, districts such as Kandhamal, Kalahandi, Rayagada, Gajapati, Nayagarh, Koraput, Mayurbhanj, and Keonjhar have been targeted under this scheme, with a focus on tribal and rainfed farmers in hilly regions who are known to be highly vulnerable to climate hazards due to low adaptive capacity (The New Indian Express, 2019).

4.3.1. Crop diversification and agroecological resilience

The Shree Anna Abhiyan (formerly Odisha Millet Mission) and the Odisha Organic Farming Policy (2018) represent pioneering efforts in integrating climate-resilient crops such as ragi (finger millet) and in promoting biodiversity-based organic farming. These initiatives minimise reliance on water- and input-intensive crops while also enhancing soil health and nutrition. Furthermore, NITI Aayog (2023) notes millets as smart crops due to their low water footprint and high resilience to dry spells and erratic rainfall, thereby making them ideal candidates for climate adaptation in Odisha's drought-prone belts.

However, a policy brief by Jena and Mishra (2021) highlights that while the Shree Anna Abhiyan has broadly focused on major millets such as ragi, the conservation and revival of minor millets, such as *Suan* (little millet), *Kangu* (foxtail millet), *Kodo* (ditch millet), and *Khira* (barnyard millet), remains critical to ensuring dietary diversity and ecosystem resilience, along with food security across multiple agroecological zones.

4.3.2. Differential resilience for marginal and women farmers

Mission *Shakti*, a national policy, has been leveraged heavily in Odisha and is currently the state's flagship women's empowerment programme. It plays a significant role in enhancing gender-inclusive access to resources, extension services, and agricredit. Women SHGs and FPOs mobilised under Mission Shakti are now participating in climate-resilient livelihoods and microenterprises (DA&FE, 2025).

In parallel, Odisha's 2025–2030 strategy targets to reach 70 lakh small and marginal cultivators (including 40% women) with enhanced access to markets, services, and technologies (Padhee et al., 2025). Coupled with the establishment of the GRC, the state, in collaboration with the International Food Policy Research Institute (IFPRI), envisions a gender-inclusive transformation for the agriculture sector in the long term.

Finally, while initiatives focused on enhancing equity have expanded women's participation, extension and decision-making processes still under-represent women farmers, limiting resilience-building. Therefore, deeper integration of gender-responsive and climate-risk-informed planning is essential to unlock the full potential of these initiatives.

4.3.3. Cross-cutting implementation considerations

Together, these schemes provide an overarching picture of the climate-adaptive farming landscape in Odisha. However, critical gaps persist. To begin with, convergence remains focused; for instance, although SAMRUDHI promotes diversification and dynamic seed rolling plans, its potential remains untapped when not aligned with irrigation investments under PMKSY or water conservation efforts under MUKTA. Moreover, targeting challenges are evident: In the case of BALARAM, which was designed to extend credit to sharecroppers and lessee cultivators, field-level bottlenecks and bank hesitancy continue to constrain its potential reach.

The sustainability of these interventions is another concern, as many (e.g., PKVY organic clusters and RAD projects) remain project-based and lack strong institutional anchoring at the panchayat or farmer collective level. This, in turn, raises doubts about long-term financing and sustainability. Furthermore, the integration of climate-risk considerations into planning can be further strengthened. As an example, irrigation potential has expanded, but actual utilisation remains heavily rain-dependent (as detailed in Box 2), thereby exposing infrastructure to rainfall variability.

5. Case Insights

While the preceding sections examine policy frameworks, institutional mechanisms, and programme design for climate-resilient agriculture in Odisha, this section presents selected case insights that illustrate how investments in digital extension, early warning, and risk-informed service delivery can strengthen adaptive capacity, reduce climate-related losses, and enhance preparedness across diverse agroecological and socio-economic contexts. The cases are intended to complement the preceding policy responses by providing empirical evidence of implementation effectiveness and highlighting pathways through which climate resilience can be operationalised at scale.

5.1. Digital advisory for resilience: The case of Krushi Samruddhi

From 2018 to 2022, the Government of Odisha, in partnership with Precision Development, launched Krushi Samruddhi, a free voice-based digital advisory service. A randomised evaluation led by Dr Shawn Cole (from Harvard Business School) included over 13,000 paddy farmers across 18 blocks in five districts of Odisha. This study found that access to real-time, localised agricultural advice significantly improved farmers' adaptive capacity to climate risks. The study further established that these extension services resulted in a 10% reduction in severe crop losses, particularly from excess rainfall and droughts. It also boosted harvest by 4.1% per season, especially in weather-affected areas.

The evaluation further found that women-headed households and those with limited access to traditional extension services benefited the most. They received guidance on drainage, seed treatment, pest control, and post-flood soil remediation. The benefit-cost ratio ranged between 6:1 and 18:1, highlighting Krushi Samruddhi's potential as a climate adaptation tool. Krushi Samruddhi's success points to the imperative role of tech-enabled, two-way extension systems in strengthening the resilience of Odisha's smallholders to weather extremes (Cole et al., 2025).



5.2. Early warning and digital preparedness: The case of SATARK

Jena and Kishore (2021) provide a detailed account of Odisha's use of digital early warning systems. The state leverages the SATARK platform (System for Assessing, Tracking, and Alerting Disaster Risk Information Based on Dynamic Risk Knowledge) to deliver real-time, hazard-specific advisories to vulnerable populations. Powered by machine learning algorithms, SATARK generates actionable, bilingual alerts in Odia and English for multiple hazards. It functions in parallel with the Early Warning Dissemination System (EWDS).

In the case of Cyclone Fani (2019), the EWDS enabled mass evacuations of 15 lakh people across 6 coastal districts within 24 hours. SATARK's integration with block, district, and state communication channels allowed Odisha to implement standard operating procedures effectively. As a result, fatalities were limited to 64 and economic losses estimated at INR 20,198 crore (USD 2.35 billion), despite wind speeds reaching 180–200 km/h. This marked a significant reduction compared with the 1999 Super Cyclone, which caused an estimated 9,843 fatalities and INR 25,000 crore in damage. Following the disastrous Fani, Odisha has continued to strengthen its early warning and disaster governance systems through institutional and community reforms. The World Bank (2023) notes that over 1,200 coastal villages are now equipped with multi-hazard alert systems, enhancing preparedness and reducing the impacts of subsequent cyclones such as Yaas and Jawad. Together, these advancements highlight the critical role of anticipatory digital systems in agricultural and disaster resilience, particularly in climate-vulnerable geographies such as coastal Odisha.



6. Strategic Interventions

It is evident from the previous sections that a climate-resilient agricultural strategy for Odisha must extend beyond infrastructure development and scheme implementation to actively enable farmers to anticipate and adapt to climate-related risks. In particular, small and marginal landholders and women require additional support in adapting to climate extremes. Multi-dimensional interventions are required to accomplish this goal; however, the following proposed actions cluster around four priority levers of change. Within each lever, we highlight illustrative interventions that demonstrate how Odisha can operationalise resilience at scale.

6.1. Enhancing water resilience through systems thinking and decentralised irrigation and conservation

There is a growing need to shift from infrastructure-centric irrigation planning to ecosystem-based, participatory water resilience planning. Achieving this at scale involves investing in decentralised, sustainable irrigation systems. This can be done by leveraging the achievements of Saura Jananidhi, which demonstrated the viability of solar-powered lift irrigation for marginal farmers. Furthermore, by expanding the use of rainwater harvesting structures, shallow tube wells, check dams, and community recharge systems, the state can foster conjunctive water use of surface and groundwater (with a focus on groundwater replenishment). These interventions need to be informed by participatory, village-level water budgeting. In parallel, there is a need to promote micro-irrigation (drip and sprinkler systems) for climate-sensitive crops such as pulses, vegetables, and oilseeds to enhance water-use efficiency and lower vulnerability to erratic rainfall. These approaches highlight the requirement of a gradual shift from centralised irrigation to climate-responsive water governance, with an emphasis on soil moisture conservation, micro-irrigation, and last-mile storage.

6.2. Building resilient cropping systems linked to state-led models

Scaling up Odisha's dynamic seed rolling plans will expand access to STVs of pigeon pea, groundnut, moong, and millets, while safeguarding indigenous genetic diversity. To achieve this, decentralised seed production should be promoted through PACSs, community seed banks, and women-led SHGs. The selection of varieties must be farmer-led and locally validated through on-farm trials, balancing climate resilience with nutritional value and crop suitability. This will prevent maladaptation by strengthening resilient and inclusive seed systems without undermining local agrobiodiversity.

Further, the SHC scheme has the potential to be further scaled up and integrated with nature-based practices such as liming, composting, green manuring, and vermiculture. This is especially required in districts (such as Keonjhar, Kalahandi, and Koraput) with mostly lateritic soil with a pH of less than 5.5 (acidic) and deficient in essential nutrients (Dixit et al., 2020). Moreover, to ensure these insights translate into action, farmers must be trained not only to collect proper soil samples but also to interpret test results. This requires imparting training on application of nutrients based on crop and soil requirements. This technical capacity is essential for enhancing nutrient efficiency, reducing dependency on chemical inputs, and supporting long-term resilience of the soil and crop productivity.

Altogether, these strategies can be advanced by promoting diversified, climate-resilient farming systems, which are suited to Odisha's agroclimatic zones. Doing so will help leverage the Price Support Scheme under SAMRUDHI (2020) to scale up cultivation of a wide range of

crops, including 14 kharif crops, 6 rabi crops, and 2 commercial crops. In parallel, advancing multi-tiered models that integrate agroforestry, livestock, fisheries, inter-cropping, and horticulture to buffer against extreme weather events, such as droughts and floods, will help provide year-round livelihoods.

6.3. Bridging agri-extension gaps through scale-up of digital climate advisories and peer-led learning networks

Platforms such as the SHG and FPO can serve as channels for targeted dissemination of seasonal advisories, pest alerts, and market intelligence through WhatsApp groups, loudspeakers, and community radio, as demonstrated by the Koraput ginger producer cluster (DA&FE, 2024). Integrating peer-to-peer learning and climate training, with trained women producers serving as local resource persons or 'climate sakhis', can leverage efforts under the Agriculture Technology Management Agency and further strengthen outreach. Currently, the Village Agricultural Worker to farmer ratio is 1:2,300, and although Krushi Samruddhi, launched in 2018, has tried to address this by providing digital extension through a push-based interactive voice response system, there remains a requirement for on-ground dissemination and in-person delivery of these trainings (Samagra, 2025). National guidelines recommend a ratio of 1:1,100 in irrigated areas, 1:750 in rainfed regions, and 1:400 in hilly areas; strengthening this alignment would further enhance the last-mile advisory support network (Pathak, 2025). Moreover, this network can be supported with exposure visits to women-led agri-enterprises and climate-resilient farms for practical learning.

Supporting SHGs and women-led FPOs in managing decentralised post-harvest assets, such as ginger drying units, solar dryers, or community cold rooms, can help improve value chains (as seen in Kandhamal and Koraput; DA&FE, 2024). Targeted capacity building in business planning, CSA practices, and extension delivery, along with incentives to host exposure visits and act as peer educators, may further enhance the expected outcomes. In response, the state is already working on improving the value chain and extension services for crops such as mango and arhar (Odisha Climate Change Cell, 2018). In addition to these efforts, climate-resilient packaging and branding can enhance shelf life and market value.

6.4. Strengthening academic–farmer–state–market linkages through the Odisha CSA Alliance (OCSAA)

Closing gaps in risk transfer and credit delivery requires collaborative platforms. Operational bottlenecks in schemes such as BALARAM can be addressed by increasing field-level staff and overcoming institutional hesitancy around credit disbursement. Besides, access for tenant farmers can be improved by streamlining JLG formation, improving bank engagement, and linking Krushak Sathis' incentives to realistic disbursement targets. Currently, Odisha covers the share of farmers' premiums under PMFBY and RWBCIS, requiring only a token payment of INR 1 to activate free insurance coverage for up to 2 ha (Orissa Post, 2023).

To build on this, outreach and enrolment efforts for schemes can be scaled up, particularly among women, tenant, and smallholder farmers. This action can also be complemented by streamlining of claim and grievance mechanisms. Expanding access to PMFBY and RWBCIS can be supported by targeted awareness campaigns and easier enrolment through SHG clusters and agri-entrepreneurs by using platforms such as SAFAL. This should ideally be embedded in a broader CSA alliance (i.e., OCSAA) that connects government, academic institutions, farmers, and private actors. Together, these entities can co-design adaptation strategies aligned with CSA and establish formal channels to strengthen knowledge sharing. In conclusion, financial tools should be better aligned with climate-risk zones and integrated into a broader system of adaptation finance, especially for tenant farmers, women, and rainfed areas.

7. Conclusion

Odisha's experience demonstrates that climate-resilient agriculture is no longer a future aspiration but an ongoing, system-wide transition. As this white paper has demonstrated, the state has built a strong foundation through sustained public investment, progressive policy frameworks, and institutionally embedded programmes across irrigation, cropping systems, extension services, and risk financing. These efforts have enabled a shift from reactive relief to more anticipatory, evidence-based resilience planning. At the same time, intensifying climate variability (through recurrent droughts, floods, cyclones, and heat stress) continues to expose structural constraints, including high dependence on rainfed agriculture, uneven utilisation of irrigation potential, soil degradation, limited access to climate-resilient inputs, and persistent inequities faced by smallholder, tenant, and women farmers. Rather than demonstrating gaps in policy, these challenges point towards the need for better alignment, coordination, and last-mile delivery.

The strategic directions outlined in this white paper emphasise that the next phase of climate-resilient agriculture in Odisha must focus on how policies are operationalised. Strengthening decentralised water governance, scaling locally validated resilient farming systems, enhancing extension through digital and peer-led models, and reinforcing risk protection through collaborative platforms coupled with training and capacity building offer a coherent pathway to translate resilience from policy design to farm-level outcomes.





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