Kaveri University Policy Brief No.2

Strategic Water Management for Sustainable Agriculture in Telangana

Aligned with PMKSY-PDMC, Climate Action & SDGs

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1. Context

1.1 Agriculture as the Backbone of Telangana's Economy

Agriculture remains a way of life in Telangana and contributes about 15.8% to the State Gross Value Added (GSVA). Telangana state having a total geographical area of 11.48 million ha (276.95 lakh acres) lays between the geographical coordinates of 15°50' and 19°55' north latitude and 77°14' and 81°19' east longitude and physiographically, broadly divided into the 'Gondwana Graben' and the 'Deccan Plateau' (GSI, 2018) (Fig.1).

Fig. 1. Geology of Telangana State

The agricultural landscape is characterized by net cropped area of 145.7 lakh acres (52.6% of the total geographical area is under cultivation) and gross cropped area of 221.7 lakh acres as of 2024, with a cropping intensity of 1.52, reflecting the multiple cropping in a single agricultural year. The net and gross irrigated area (2024) is estimated at 95.6 lakh acres and 160 lakh acres with an irrigation intensity of 1.67 (DES, 2024), and groundwater contributing nearly 89% of total irrigation, indicating high dependence on wells. The operational holdings are estimated at 7.06 million and an average landholding size of 0.91 ha (varying from 0.60 ha in Medak to 1.53 ha in Adilabad), underscoring the dominance of small and marginal farmers.

Geographically, the state is in a semi-arid zone having predominant hot and dry climate and largely drained mainly by two major rivers systems—the Godavari and the Krishna—along with several tributaries such as Bhima, Manair, Manjira, and Musi, which together define Telangana's surface water hydrology.

Telangana has emerged as a top food grain producer in India, with rice being the dominant crop (2nd largest producer in India), boasting a production of 171.13 lakh Metric Tonnes (MT) and Maize at 26.68 lakh MT. The state achieved a record 16.42% annual growth in food grain production from 2018-19 to 2023-24, leading to a 25.8 million metric ton production in 2022-23. Other major crops include pulses (red gram, soybean, bengal gram & greengram), oilseeds (groundnut, sesame, sunflower & safflower), cotton, sugarcane, turmeric, chillies, mango, guava, sweet orange and vegetables (beans, gourds, bhendi, tomato, brinjal etc).

Policy Relevance:

- PMKSY-PDMC: Enhancing irrigation efficiency and reducing groundwater stress
- SDGs: SDG-2 (Zero Hunger), SDG-6 (Clean Water), SDG-1 (No Poverty)

1.2 Water as a Strategic and Limiting Resource

Water is the most critical and limiting natural resource for Telangana's agriculture. The State faces multiple, interlinked stresses—low and erratic rainfall, declining groundwater tables (0.22 m per year), degradation of soil and water quality, changing cropping patterns, demographic pressures, rapid urbanization, and increasing climate variability. These pressures are fundamentally altering the natural resource base supporting agriculture. Under such circumstances, "business-as-usual" water management approaches are no longer viable, and a paradigm shift toward climate-resilient, water-efficient, and resource-conserving agriculture is urgently required.

Policy Relevance:

- Climate Action: Adaptation to rainfall variability and drought risk
- SDG-13 (Climate Action), SDG-15 (Life on Land)

1.3 Rainfall Characteristics

The state receives an annual rainfall from 683 mm in 48 rainy days (Jogulamba Gadwal in south) to 1293 mm in 70 rainy days (Jayashankar Bhupalpally in north) with average annual rainfall of 902 mm in 50 days. The amount of rainfall and their distribution in different districts exhibit a longer growing period over the northern districts receiving higher rainfall viz., Bhadradri Kothagudem (1248 mm in 73 days), Komurambheem Asifabad (1247 mm in 67 days), and Mancherial (1211 mm in 67 days) and shorter periods over the southern districts with least rainfall and rainy days viz., Nagarkurnool (697 in 49 days) and Mahabubnagar (729 mm in 53 days) (Fig. 2).

Approximately 80 – 85% of rainfall occurs during south-west monsoon months (June – September) and is the main source of recharge to groundwater. For example, during the year 2004–05, the state received deficit rainfall (–30%) and deep-water levels were observed (14 m bgl) and subsequent year it received excess rainfall (+19%) where a rise of 2.1 m was observed (Madhnure and Lavanya, 2021). Further, high rainfall variability is observed, with higher coefficients of variation in the southern region compared to the north (Fig. 2). Climate studies from 1901–2015 indicate 77 normal, 22 deficient, 14 excess, and 2 scanty years (Murali et al., 2022). However, some studies conclude that Telangana is witnessing an overall increase in rainfall, particularly in its northern and eastern districts, along with a rise in extreme rainfall events. These changes present challenges for water resource management and agriculture, underscoring the need for adaptive strategies to cope with shifting monsoon patterns in a warming climate.

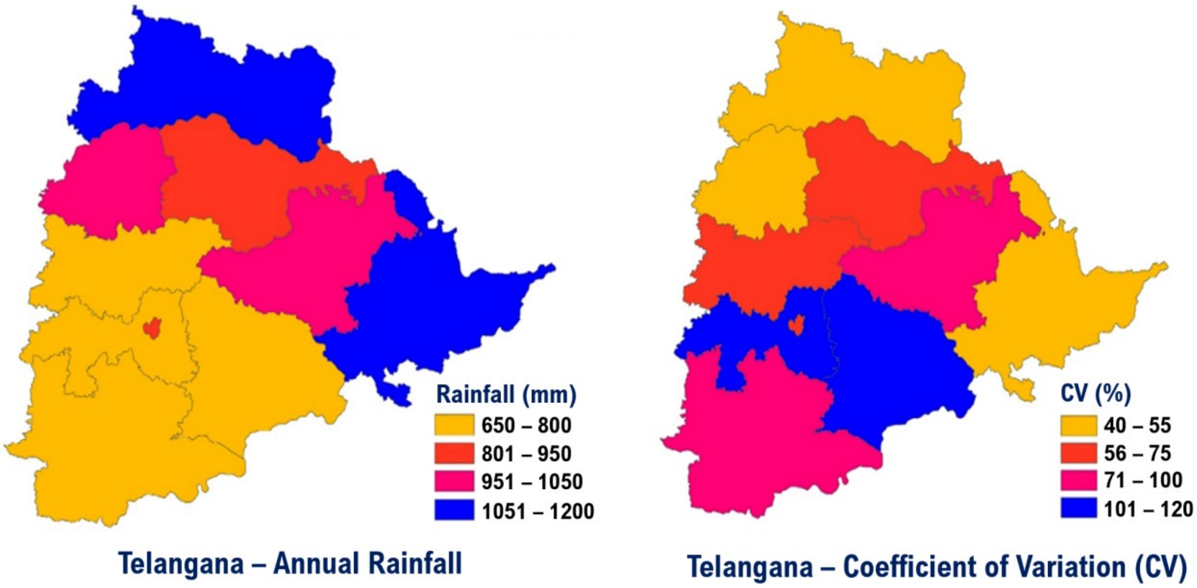

Fig. 2. Telangana - Mean annual rainfall and Coefficient of variation

1.4 Groundwater Scenario

This variation in rainfall has been shown to have an impact on groundwater depth across the state (Fig. 3) (Dubey et al., 2021). Districts with substantial annual rainfall fall into the group of districts with very shallow groundwater depths. Districts with minimal annual rainfall, on the other hand, reveal that the water depth is extremely deep in most parts of the district (Fig. 3).

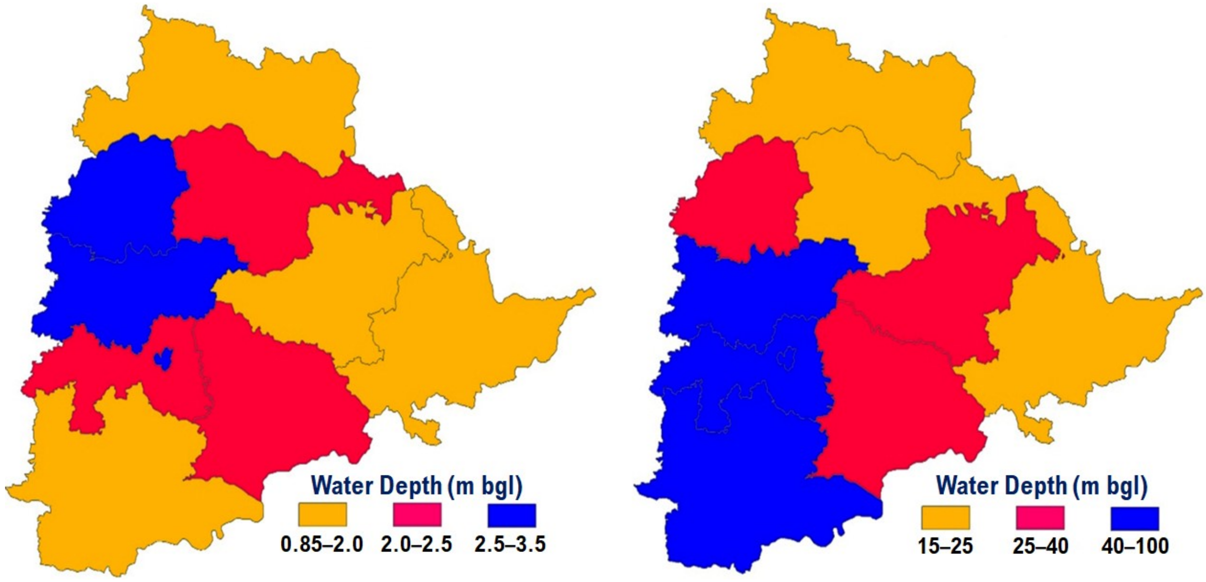

Fig. 3. Groundwater depth – minimum and maximum in Telangana

The average annual groundwater levels during last 34 years are 9.32 m below ground level (m bgl) (Madhnure and Lavanya, 2021). These water levels display three distinct patterns, 1st up to 2004–05 where shallow water levels (average water level of 8.6 m bgl) showing falling trends @0.4 m/year were observed, 2nd between 2005–06 and 2013–14 having moderate groundwater levels (average water level of 10.1 m bgl) and showing rising trends @0.08 m/year and 3rd between 2014–15 and 2018–19 (after formation of state), with deep water levels (average of 11.50 m bgl) and rising trends @0.11 m/year. But these water levels are not evenly distributed as observed during pre and postmonsoon season of 2019, where, shallow water levels (<10 m bgl) occur in northern and eastern part, deeper (>20 m bgl) in central and western parts and moderate (10–20 m bgl) in rest of the areas.

Policy Relevance:

- PMKSY: Emphasis on rainwater harvesting and drought proofing
- SDG-6.4: Efficient and sustainable withdrawals of freshwater

1.5 State-Level Water Balance – Indicative Assessment

Based on an average annual rainfall of 902 mm, the estimated state-level water balance is as follows:

- Total rainfall received: 10.12 million hectare-metres (m ha m)
- Surface runoff (40%): 4.048 m ha m
- Groundwater recharge (9%): 0.9108 m ha m
- Evapotranspiration losses (41%): 4.1492 m ha m
- Soil moisture storage (10%): 1.012 m ha m

These figures represent broad averages; actual values vary widely across basins depending on rainfall, land use, soil type, and watershed interventions. In addition to rainfall, Telangana receives allocated surface inflows through inter-state rivers, subject to legal and institutional arrangements.

Policy Relevance:

- PMKSY-WDC & PDMC: Improving capture, storage, and productive use of rainfall
- Climate mitigation: Reducing non-productive losses (ET, runoff)

1.6 Need for Integrated and Forward – Looking Water Management

Given the finite, variable, and contested nature of water resources, careful and judicious management is essential to meet competing demands from agriculture, domestic, industrial, and environmental sectors. There is an urgent need to anticipate future climate and demand scenarios and develop institutional, technological, and financial pathways that ensure food and nutritional security without undermining long-term land and water sustainability. This is central to achieving State and national development objectives in a changing climate.

1.7 Key Considerations for Future Agricultural Water Management

Future strategies must recognize that:

- Sustained growth in agriculture and allied sectors will increase pressure on water resources.
- Regional imbalances necessitate basin- and agro-climatic-specific planning, particularly for drought-prone areas.
- Municipal and industrial water demand is rising rapidly and must be met from the same finite resource base.
- Agriculture's share of freshwater is likely to decline, requiring major gains in water application efficiency and water productivity.
- Agricultural water use must be fully integrated with overall water resources planning, ensuring ecosystem protection and sustainability.

Policy Relevance:

- PMKSY-PDMC: "More crop per drop"
- SDGs: SDG-6, SDG-12 (Responsible Consumption), SDG-13

2. The Water Challenges (Aligned with Strategic Objectives)

Telangana faces a complex and interlinked set of water challenges driven by rising demand, climatic variability, degradation of traditional water systems, and growing stress on groundwater resources. Ensuring long-term water security for agriculture, ecosystems, and livelihoods requires urgent and integrated action across the following critical areas:

a) **Sustainable Use of Water Resources:** Over-extraction of rivers, tanks, and especially groundwater is threatening the long-term availability of water in Telangana. Unsustainable withdrawals undermine ecosystem health, reduce future water supplies, and create serious inter-generational equity concerns. Sustainable extraction limits must be defined based on basin hydrology, recharge potential, and climate variability, supported by real-time monitoring and regulatory mechanisms at basin and watershed scales.

b) **Low Irrigation Water Use Efficiency:** Agriculture remains the dominant consumer of water in the state, while municipal and industrial demands are increasing rapidly. Current irrigation efficiencies in many systems remain low, leading to substantial wastage through conveyance losses, over-irrigation, and inefficient field application. A study of 35 projects in different states of India by Central Water Commission (CWC) revealed that the conveyance efficiency, on-farm application efficiency and overall project water use efficiency varied from 48 to 83%, 27 to 75% and 13 to 62%, respectively with a corresponding weighted average of 69%, 55% and 36% (CWC, 2016). Improving irrigation water-use efficiency is therefore a top priority to sustain agricultural growth, enhance water productivity, and balance competing sectoral demands.

c) **Large Yield Gaps in Irrigated Agriculture:** Despite significant investments in irrigation infrastructure, crop productivity in many command areas remains far below achievable levels. Yield gaps (Fig. 4 and 5) between genetic potential, demonstration yields, and actual farmer-field performance in diverse crops range from 13.4 to 71.1% in cereals, 24.2 to 45.0% in pulses, 14.6 to 47.6% in oilseeds, 9.2% cotton, 39.2 to 70.8% in vegetables, and 46.2 to 58.3% in fruits (MoA&FW, 2025).

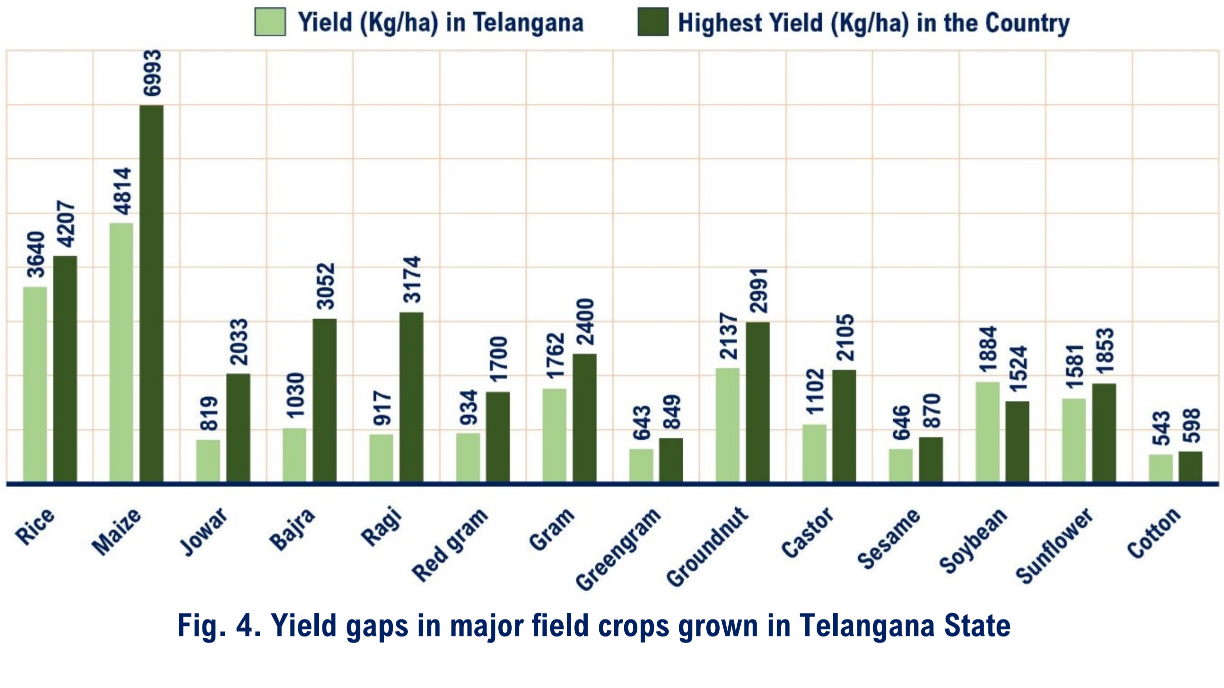

Fig. 4. Yield gaps in major field crops grown in Telangana State

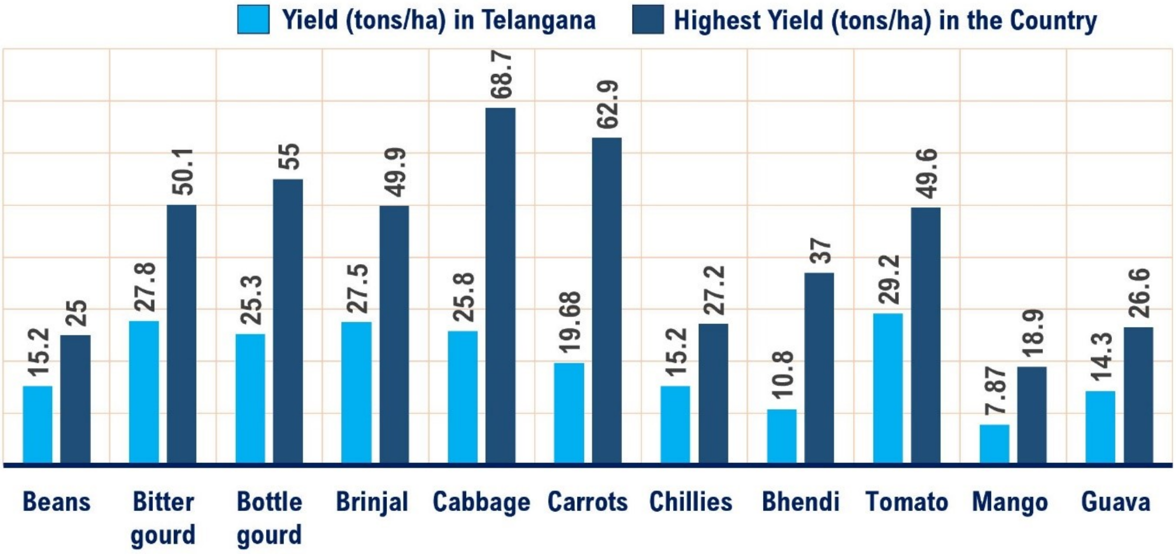

Fig. 5. Yield gaps in major horticultural crops grown in Telangana State

These gaps are largely due to incomplete adoption of good agricultural practices, suboptimal agronomy (low yielding varieties, delayed sowing, improper irrigation & fertilizer management), pest and disease losses, and limited access to timely advisory and inputs. Bridging these gaps offers one of the most cost-effective pathways for increasing farm incomes without expanding water use.

d) **Low Productivity and High Risk in Rainfed Areas:** Telangana's dryland districts exhibit considerable climate vulnerability owing to their semi-arid agro-ecological conditions, high dependence on rainfed agriculture, and increasing climate variability (Jabeen et al., 2026). Districts such as Adilabad, Nagarkurnool, Nalgonda, Mahabubnagar, Jogulamba-Gadwal, Suryapet, Wanaparthy, Peddapalli, and Yadadri are particularly at risk due to recurrent droughts, water scarcity, and limited adaptive capacity (Kadiyala et al., 2021; Jabeen et al., 2026). These regions are highly sensitive to erratic rainfall patterns, groundwater depletion, and frequent borewell failures, which directly affect agricultural productivity and farmer livelihoods. A substantial proportion of mandals and rainfed agricultural areas fall within moderate to high agricultural drought vulnerability categories. Socio-economic constraints, including low farm profitability, small landholdings, and limited access to adaptive technologies, further intensify climate risks (Jabeen et al., 2026). Climate projections suggest that these vulnerabilities are likely to increase by mid-century, underscoring the urgent need for climate-resilient agricultural practices, improved water resource management, and strengthened institutional support systems to enhance long-term sustainability and rural resilience.

e) **Pollution and Degradation of Water Resources:** Water quality across Telangana is progressively deteriorating due to untreated municipal sewage discharge, industrial effluents, agricultural runoff, indiscriminate use of chemical fertilizers and contamination of surface tanks and groundwater aquifers, thereby reducing the availability of potable and irrigation-quality freshwater. This deterioration poses risks to public health, irrigation suitability, soil physicochemical properties, and aquatic ecosystem integrity. Irrigation water is typically neutral to moderately alkaline (pH ~7.0–8.4) with low to moderate salinity and low sodium, predominantly classified under C_2S_1–C_3S_1 irrigation water classes (Sakram and Narsimha, 2018; Sushma et al., 2022). Groundwater, the dominant irrigation source, frequently exhibits elevated hardness, fluoride, nitrate concentrations, and localized salinity hazards influenced by hydrogeochemical conditions and anthropogenic inputs (Narsimha et al., 2020). Spatial variability in electrical conductivity (EC) and total dissolved solids (TDS) is pronounced across districts. Prolonged irrigation with alkaline water may induce soil sodicity, permeability constraints, and nutrient imbalances without appropriate soil management interventions. Surface water bodies near urban centres often show elevated COD, BOD, and TDS levels, reflecting anthropogenic contamination. Integrated wastewater treatment, stricter regulatory enforcement, and systematic hydrochemical monitoring are therefore critical for sustaining water quality and long-term agricultural productivity in Telangana.

f) **Fragmented and Weak Water Governance:** Water management responsibilities remain distributed across multiple departments with limited coordination. Effective and sustainable water management requires integrated governance frameworks supported by clear legislation, harmonized institutional mechanisms, sound and reliable water information systems, including high-quality data sets on availability, use, demand, and quality, and applied research. Evidence-based planning and monitoring, transparent reporting, continuous applied research are essential to assess current conditions and anticipate emerging risks are essential to evaluate management options, support equitable allocation, sustainability, and climate resilience.

g) **Limited Community Participation:** Sustainable water security requires participatory and decentralized water governance supported by strong and effective institutional arrangements. Greater awareness and responsibility for water management must be fostered at all levels—individual households, farming communities, local institutions, and government agencies. Community-based approaches such as Water User Associations, watershed committees, and participatory irrigation management can enhance accountability, equity, and efficient resource use. Special emphasis must be placed on inclusive decision-making, ensuring the active participation of women, tenant farmers, and landless households who are often most vulnerable to water scarcity. Empowering these groups strengthens social ownership, improves local stewardship of water resources, and ensures that water management policies are more equitable, responsive, and sustainable.

h) **High Water Intensity of Crops and Cropping Systems:** High water intensity of cropping systems, particularly rice cultivation, exerts significant pressure on Telangana's water resources. Rice typically requires about 1,600–2,000 mm/ha of water and accounts for nearly 50–55% of the net irrigated area in the state. This high water demand contributes to groundwater depletion, canal command water stress, localized waterlogging, and secondary salinity risks. Continuous flooded rice cultivation also increases methane emissions (6 tons/ha CO_2-e), raising concerns regarding agricultural greenhouse gas footprints. The expansion of irrigated paddy in semi-arid regions further amplifies climate and water sustainability challenges. Diversification toward less water-intensive crops, along with water-saving practices such as Alternate Wetting and Drying (AWD), direct-seeded rice (DSR), and precision irrigation methods including drip systems in suitable commands, is therefore critical for improving water productivity and long-term resource sustainability.

3. Water Resource Development & Management Strategies for Agricultural Use

Water resource development and management for agriculture involves a continuum of interlinked actions:

1. Basin-level planning and development of water resources
2. Efficient conveyance from source to farm
3. Precision on-farm water application for optimal productivity

Rainfall, surface water, and groundwater must be managed conjunctively, recognizing competing sectoral demands and allocating water equitably and efficiently to balance food security, livelihoods, and ecosystem needs. Crops must receive water at the right time, in the right quantity, and through the right method, guided by crop physiology, soil moisture, and evapotranspiration demand. Scientific irrigation scheduling, micro-irrigation, and precision water management are central to PMKSY-PDMC objectives. Surplus water and agricultural return flows should be reused or safely disposed of to prevent pollution from fertilizer and pesticide residues. Drainage, reuse, and recycling are integral to sustainable systems. Water quality management is equally critical. Poor-quality water requires ameliorative measures, while agricultural practices must minimize contamination of shared water sources, particularly those used for drinking water supply.

Achieving sustainable agricultural water use therefore requires a multi-pronged strategy integrating engineering, agronomic, institutional, and governance interventions, contributing directly to:

- PMKSY-PDMC: Water-use efficiency and productivity
- Climate Action: Adaptation, resilience, and mitigation
- SDGs: SDG-2, SDG-6, SDG-12, SDG-13

Key Strategies & Action Plan For Sustainable Utilization of Water Resources in Agriculture Sector are detailed in Annexure – I.

Literature Cited

GSI. 2018. Glimpses of GSI Activities in Telangana. State Unit Telangana, Geological Survey of India, Southern Region, Hyderabad, 34p.

DES. 2024. Statistical Year Book, Department of Economic and Statistics, Government of Telangana, Hyderabad.

Dubey, A., Bagade, B., Kumar, S. and Devi, K. 2021. Impact of Precipitation Variability on Ground Water Resources: A Comparative Assessment of Indian States. Geo-Eye. 10: 5 – 12.

Murali, A. *et al.* (2022). Trend Analysis of Precipitation (1901–2015) over Telangana State, India. In: Islam, M.N., Amstel, A.V. (eds) India II: Climate Change Impacts, Mitigation and Adaptation in Developing Countries. Springer Climate. Springer, Cham. https://doi.org/10.1007/978-3-030-94395-0_15.

Madhnure, P. and Lavanya, B. 2021. Development of Groundwater Irrigation in Telangana State: Challenges, Management and Way Forward. Journal Of Geological Society of India 97: 271–281

MoA&FW. 2025. All India Crop-wise Area, Production & Yield estimates. The Ministry of Agriculture & Farmers Welfare via the Unified Portal for Agricultural Statistics (UPAg) and Directorate of Economics & Statistics (DES), Government of India.

Jabeen, A., Goudappa, S.B., Dixit, S., Shashidhara K.K., Hulagur, B., Amrutha, T.J. and Kumar, K.M. 2026. Farmers' Perception of Climate Change Vulnerability in Dryland Telangana. Journal of Scientific Research and Reports 32: 107 - 114.

Kadiyala, M.D.M., Gummadi, S., Irshad, M.A., Palanisamy, R., Muralikrishna, G. and Whitbread, A. 2021. Assessment of climate change and vulnerability in Indian state of Telangana for better agricultural planning. Theoretical and Applied Climatology **143**: 309–325.

Sushma, S., Bindu, G.S.M., Neelima, T.L. and Umadevi, M. 2022. Characterization of irrigation water quality of groundnut belt of erstwhile Mahbubnagar district of Telangana. Environment Conservation Journal 23: 285-294.

Narsimha, A., Ratnakar, D., Anusree, K. and Kumar T.A, 2020. Appraisal of groundwater quality for drinking and irrigation purposes in Central Telangana, India. Groundwater for Sustainable Development 10: 100334, https://doi.org/10.1016/j.gsd.2020.100334.

Sakram, G. and Narsimha, A. 2018. Hydrogeochemical characterization and assessment of water suitability for drinking and irrigation in crystalline rocks of Mothkur region, Telangana State, South India. Applied Water Science 8:143 https://doi.org/10.1007/s13201-018-0787-6.

ANNEXURE – I

STRATEGIES & ACTION PLAN FOR SUSTAINABLE UTILIZATION OF WATER RESOURCES IN AGRICULTURE SECTOR

S. No.	Activity	Goal	Action
Irrigation & CADA			
1	**Completion of Ongoing Irrigation Projects**	Create and optimally utilize the state's estimated ultimate irrigation potential (12.75 million acres) through the timely completion of ongoing projects and scientifically planned development of new irrigation infrastructure. Expanding assured irrigation coverage is essential for sustaining projected agricultural growth, enhancing cropping intensity, ensuring food and nutritional security, and supporting long-term economic development and rural livelihoods. While Telangana has achieved near self-sufficiency in rice production, significant deficits persist in key commodities, particularly pulses (approximately 5.8 lakh tonnes), oilseeds (about 6.0 lakh tonnes), vegetables (40 lakh tonnes) and fruits (5.0 lakh tons). Future irrigation development must therefore support crop diversification toward less water-intensive, high-value, and nutritionally important agri-horticultural crops to improve farm incomes, resource-use efficiency, and agricultural sustainability.	**Scientific Project Planning:** Undertake comprehensive investigations and preparation of high-quality Detailed Project Reports (DPRs), incorporating hydrological assessments, climate variability considerations, Environmental Impact Assessments (EIA), and social safeguards.
	Construction of New Projects Depending on the Availability of Resources		**Basin-Based Planning Approach:** Adopt river basin and sub-basin units as the fundamental planning framework for irrigation development to ensure integrated water resources management, equitable allocation, ecological sustainability, and efficient inter-sectoral coordination.
			Timely Resource Mobilization and Execution: Ensure adequate financial provisioning, streamlined administrative approvals, and robust project management systems to facilitate time-bound completion of irrigation projects.
			Integrated Command Area Development: Align irrigation expansion with efficient water management practices, crop diversification strategies, and adoption of water-saving technologies to maximize agricultural productivity and water-use efficiency.
2	**Water User Associations**	Strengthen participatory irrigation management by enhancing community involvement in water distribution, regulation, and sustainable resource management. Water User Associations serve as critical decentralized institutions to improve irrigation efficiency, equity in water access,	**Institutional Strengthening:** Establish and operationalize Water User Associations across canal, tank, and groundwater irrigation command areas with inclusive representation of farmers, women, tenant cultivators, and other vulnerable stakeholders.
			Technical and Administrative Support: Provide WUAs with adequate technical guidance, administrative backing,

		accountability, and community ownership of irrigation systems.	and financial support for operation and maintenance of irrigation infrastructure, equitable water allocation, and system upkeep.
			Capacity Building: Implement structured training programmes on irrigation scheduling, water-use efficiency, conflict resolution, climate-resilient water management, and participatory governance.
			Inter-Departmental Linkages: Foster strong coordination between WUAs and irrigation, agriculture, watershed, and rural development departments to enhance convergence of programmes and effective resource management.
3	**Equity in Irrigation Systems**	Promote equitable and reliable access to irrigation water across command areas, with particular emphasis on ensuring timely supplies to tail-end farmers in canal and tank irrigation systems. Strengthening irrigation equity is critical for enhancing agricultural productivity, reducing regional disparities, improving livelihood security, and ensuring socially inclusive water governance.	**Institutionalizing Equitable Water Distribution:** Promote scientifically designed rotational water distribution systems (Warabandi) supported by transparent allocation mechanisms, digital monitoring, and participatory oversight to ensure fair access across head, middle, and tail reaches.
			Conjunctive Water Resource Management: Advocate integrated use of surface and groundwater resources in major irrigation commands to enhance supply reliability, optimize water resource utilization, and prevent unsustainable groundwater extraction.
			Strengthening Command Area Development: Prioritize investments in on-farm infrastructure—including field channels, land levelling, land shaping, and water control structures—to improve last-mile water delivery efficiency and minimize conveyance losses.
			Inclusive Irrigation Governance: Strengthen Water User Associations and local institutions to support participatory decision-making, conflict resolution, and equitable water sharing, particularly benefiting smallholders and tail-end farmers.

4	**Tank Irrigation**	Revitalize and sustain tank irrigation systems through restoration of storage capacity, improved maintenance, and strengthened community-based management. Tank systems play a critical role in supporting irrigation, groundwater recharge, livestock needs, and ecological services, particularly in semi-arid and rainfed regions.	**Restore Tank Storage Capacity:** Undertake systematic desiltation of tanks to recover lost water-holding capacity and improve irrigation reliability.
			Strengthen Infrastructure and Safety: Reinforce tank bunds and embankments, repair sluices and surplus weirs, and improve conveyance structures to ensure long-term functionality.
			Prevent Degradation and Protect Tank Assets: Remove encroachments and safeguard tank catchments to preserve their hydrological role and ecosystem value.
			Promote Productive Reuse of Tank Silt: Encourage the application of nutrient-rich tank silt in cropped fields to enhance soil fertility and improve agricultural productivity.
			Institutionalize Participatory Management: Form and empower Water User Associations (WUAs) for local operation, maintenance, equitable water distribution, and sustainable governance of tank irrigation systems.
5	**Irrigation Efficiency**	Enhance irrigation efficiency across existing surface and groundwater irrigation systems to ensure optimal use of scarce water resources. Available assessments indicate that overall irrigation efficiencies in different projects range widely from 17% to 46%, highlighting substantial scope for improving conveyance, distribution, and on-farm application. Improving efficiency is	**Real-time Performance Assessment:** Establish integrated monitoring of irrigation project performance using Remote Sensing (RS), GIS applications, and digital decision-support systems for evidence-based planning, allocation, and management.
			Reduce Conveyance Losses: Prioritize lining of canals and distributaries in reaches with high seepage and leakage losses to improve conveyance efficiency and reduce waterlogging.
			Strengthen On-farm Development: Implement comprehensive command area development measures including land consolidation, field channels, watercourses, field drains, land levelling, and land shaping to ensure uniform and efficient water delivery at the farm level.

		essential to reduce wastage, expand effective irrigated area, and maximize agricultural returns from every unit of water delivered.	**Promote Efficient Irrigation Methods:** Accelerate adoption of micro-irrigation, sprinkler systems, precision irrigation scheduling, and water-saving agronomic practices to improve application efficiency.
			Encourage Water-Efficient Cropping Systems: Support diversification towards less water-intensive crops and climate-resilient cropping patterns, especially in stressed command areas, to improve water productivity.
			Maximize Value Per Unit of Water: Evolve an agricultural production system that minimizes avoidable losses, curbs wastage, and enhances "more crop and more income per drop" through integrated water and nutrient management.
			Reform Water Pricing and Regulation: Develop clear, socially equitable water pricing policies based on demand-sensitive and volumetric principles, supported by appropriate regulatory mechanisms, to encourage conservation while safeguarding poor and marginal farmers.
6	**Drainage in Irrigation Systems**	Ensure the effective removal of excess water from irrigated command areas to prevent waterlogging, maintain soil health, and sustain an optimal salt balance. Adequate drainage is essential for protecting long-term agricultural productivity, avoiding salinity build-up, and ensuring the sustainability of irrigation investments.	**Integrate Drainage Infrastructure:** Provide appropriate surface and subsurface drainage provisions in both new and existing irrigation systems, particularly in canal and tank command areas prone to waterlogging and salinity.
			Prevent Land Degradation: Implement drainage management measures to control rising water tables, reduce soil salinization, and safeguard productive agricultural lands.
			Promote Safe Reuse of Drainage Water: Encourage the controlled utilization of drainage effluents for irrigation, wherever feasible, subject to acceptable water quality standards and suitable crop tolerance levels
			Strengthen Monitoring and Management: Establish regular monitoring of soil salinity, groundwater levels, and

			drainage water quality to ensure environmentally safe and agronomically sustainable reuse practices.
7	**Managing Below-Normal Reservoir Water Inflows**	Strengthen preparedness and response mechanisms for deficit water conditions arising from below-normal inflows into reservoirs. Effective management during drought years and low-storage periods is essential to minimize agricultural losses, sustain livelihoods, and ensure equitable distribution of limited water resources.	**Promote Water-Efficient Crops and Cropping Systems:** Encourage diversification towards less water-intensive crops, short-duration varieties, and climate-resilient cropping patterns to reduce irrigation demand under constrained water availability.
			Develop Distributary-Level Contingency Delivery Plans: Prepare and implement operational contingency plans for water releases and irrigation scheduling at the level of individual distributaries, minors, and pipe outlets to ensure transparent, equitable, and need-based allocation during shortages.
			Improve Utilization of Soil Moisture Reserves: Adopt water budgeting approaches that maximize the effective use of water stored in the root zone through better irrigation timing, critical-stage irrigation, and soil moisture conservation practices.
			Apply Deficit Irrigation Strategies: Use scientifically guided deficit irrigation concepts and crop-specific water production functions to allocate limited water optimally, minimizing yield reductions while maximizing overall system productivity.
		Strengthen evidence-based irrigation governance through systematic data collection, monitoring, and	**Establishment of a State Water Informatics Centre:** Create a dedicated institutional platform for integrated, data-driven water governance responsible for systematic collection, collation, analysis, and dissemination of irrigation and hydrological data across the state.
			Integrated Water Information Systems: Develop comprehensive databases covering weather parameters, soil moisture, crop conditions, reservoir storage, canal

8	**Data Collection, Evaluation and Monitoring of irrigation systems**	performance evaluation of irrigation systems. Continuous appraisal is essential to validate project assumptions, identify inefficiencies, enhance water-use efficiency, ensure equitable distribution, and improve climate resilience in agricultural water management.	flows, groundwater levels, and water quality to support informed decision-making.
			Digital Monitoring and Decision Support: Leverage modern technologies such as Management Information Systems (MIS), GIS platforms, Remote Sensing, IoT-enabled sensors, and real-time digital dashboards for transparent monitoring, adaptive management, and efficient water allocation.
			Transparency and Data Accessibility: Promote open and accessible water data systems to enhance accountability, strengthen stakeholder confidence, and support participatory water governance.
			Climate-Responsive Water Management: Utilize real-time data and analytics for contingency planning during deficit inflow years, drought management, and optimization of irrigation scheduling.
9	**Catchment & Command area treatment**	Strengthen the sustainability and efficiency of irrigation systems by reducing sediment inflow and siltation in reservoirs, tanks, and irrigation projects. Effective catchment and command area treatment enhances storage capacity, prolongs infrastructure life, improves groundwater recharge, safeguards ecosystem services, and supports long-term water security.	**Integrated Catchment Conservation:** Promote comprehensive soil and water conservation interventions across catchments, including contour bunding, vegetative barriers, check dams, gully control measures, and erosion management to reduce runoff and sediment transport.
			Afforestation and Ecological Restoration: Encourage plantation of basin-specific tree, shrub, and grass species to stabilize soils, enhance biodiversity, reduce erosion, and strengthen hydrological balance.
			Watershed-to-Command Integration: Adopt a holistic approach linking catchment treatment with command area management to improve irrigation efficiency, groundwater recharge, and overall basin sustainability.
			Institutional Convergence: Strengthen coordination among key departments—including Irrigation, Forest,

			Watershed Development, Agriculture, Rural Development, and Water User Associations—to ensure integrated planning, implementation, and monitoring.
			Community Participation and Stewardship: Promote participatory approaches involving local communities, WUAs, and farmer groups to enhance ownership, maintenance, and sustainability of conservation interventions.
10	**Eco-Tourism and Environmental Stewardship**	Promote eco-tourism as a sustainable development strategy that supports conservation of water ecosystems, enhances biodiversity, and improves livelihoods of local communities. Eco-tourism around reservoirs, lakes, wetlands, and tank systems can foster environmental awareness, strengthen ecosystem stewardship, and generate green economic opportunities while safeguarding natural resources.	**Ecosystem Restoration and Conservation:** Promote restoration of natural landscapes around water bodies through shoreline stabilization, wetland rehabilitation, catchment protection, and biodiversity enhancement to sustain ecological balance and water quality.
			Habitat Development and Biodiversity Promotion: Encourage creation of suitable habitats to attract and conserve inland and migratory bird species, aquatic biodiversity, and native vegetation while maintaining ecological integrity.
			Sustainable Infrastructure Development: Promote eco-friendly landscape beautification, nature trails, bird-watching zones, and low-impact tourism infrastructure that align with environmental sustainability principles.
			Environmental Education and Awareness: Establish Eco-Interpretation and Nature Education Centres near major water bodies to promote awareness on water conservation, biodiversity protection, and sustainable resource management among citizens, students, farmers, and visitors.
			Community Participation and Green Livelihoods: Encourage involvement of local communities, Water User Associations, self-help groups, and rural enterprises in eco-tourism activities to generate livelihood opportunities while strengthening stewardship of water ecosystems.

11	**Training & Capacity building of stakeholders**	Strengthen the technical, managerial, and institutional capacities of stakeholders involved in agricultural water management to support sustainable, efficient, and equitable use of water resources. Capacity building should enhance operational competencies, strategic planning capabilities, leadership skills, and institutional readiness for climate-resilient and evidence-based water governance.	**Institutionalized Capacity Development Framework:** Design and implement structured, customized training programmes leveraging national and international expertise, experienced practitioners, academic institutions, and innovation ecosystems to address emerging water and agricultural challenges in Telangana.
			Alignment with State and National Priorities: Ensure capacity-building initiatives support climate resilience, water-use efficiency, sustainable intensification, digital agriculture, and integrated water resources management frameworks.
			Priority Training Domains: ▪ Climate-resilient agriculture and water management systems ▪ Soil–water–plant interactions and crop physiology ▪ Scientific irrigation scheduling and crop water requirements ▪ Water-saving irrigation technologies (micro-irrigation, AWD, precision irrigation) ▪ Soil health management and integrated nutrient–water management ▪ Farm mechanization and resource-use efficiency ▪ Good Agricultural Practices (GAP), value addition, and agribusiness development ▪ Monitoring and evaluation of irrigation systems ▪ Digital water governance tools including MIS, Remote Sensing, GIS, automation, and data-driven decision support systems
			Participatory and Practice-Oriented Learning Approach: Promote field-based, participant-centered training models emphasizing experiential learning, peer-to-peer exchange, interdisciplinary skills, exposure visits, modern tools and digital technologies, and problem-solving workshops linked to real-world challenges.

12	**Creation of Strategic Linkages and Partnerships**	Strengthen institutional capacity to address emerging water and agricultural challenges through coordinated, participatory, and partnership-driven approaches. Building strong inter-institutional linkages is essential for enhancing the effectiveness, sustainability, equity, and efficiency of water resource management across the state.	**Institutional Convergence and Coordination:** Promote structured collaboration among key government departments—including Irrigation and Command Area Development (CADA), Agriculture, Horticulture, Agro-Industries, Watershed Development, Forest, Rural Development, and District Administration—to ensure integrated planning, efficient resource utilization, and coherent policy implementation.
			Science – Policy – Practice Interface: Strengthen partnerships with agricultural universities, research institutions, and technical organizations to support evidence-based policymaking, innovation dissemination, capacity building, and adaptive water management strategies.
			Global Knowledge Partnerships: Facilitate collaboration with leading international water and agricultural institutions (e.g., IWMI, ARO–Israel, Wageningen University, University of Florida, and similar centres of excellence) to leverage global best practices, advanced technologies, and research-driven solutions.
			Community and Stakeholder Engagement: Enhance linkages with Water User Associations, Farmer Producer Organizations, civil society organizations, and NGOs to promote participatory irrigation management, local stewardship, and inclusive decision-making processes.
Groundwater Department			
1	**Groundwater Development**	Ensure sustainable utilization of groundwater resources by restricting extraction within estimated recharge and extractable limits while promoting long-term aquifer health and water security.	Delineate potential, critical, and over-exploited groundwater zones through hydrogeological assessments to guide sustainable extraction and planning interventions.
			Strengthen regulatory mechanisms for groundwater abstraction in over-exploited areas and implement

			targeted artificial recharge and aquifer restoration projects.
			Develop predictive groundwater models integrating monsoon rainfall variability, recharge dynamics, and extraction trends to support contingency crop planning and water-use optimization.
			Undertake systematic aquifer mapping and characterization to assess groundwater quantity and quality, enabling participatory aquifer management involving local communities and stakeholders.
			Promote conjunctive use of surface and groundwater in canal and tank command areas to optimize water availability, stabilize ayacut irrigation, and reduce pressure on groundwater resources.
2	**Augmenting Groundwater Resources**	Stabilize groundwater levels and promote sustainable groundwater use through enhanced recharge, improved water harvesting infrastructure, and integrated resource management.	Enhance groundwater recharge through rainfall harvesting interventions, including restoration and rejuvenation of approximately 46,000 tanks, construction of recharge structures, and watershed-based recharge measures.
			Develop a comprehensive inventory of existing water harvesting and recharge structures and undertake systematic repair, renovation, and modernization to improve their functional efficiency and recharge potential.
			Promote targeted artificial recharge interventions such as rooftop rainwater harvesting, recharge shafts, percolation tanks, injection wells, and recharge borewells to strengthen aquifer replenishment, particularly in groundwater-stressed regions.
3	**Groundwater Management**	Promote judicious and sustainable utilization of groundwater resources through efficient water-use practices, crop diversification, and participatory aquifer management aligned with the “more crop per drop” principle.	Implement the National Project on Aquifer Management (NAQUIM) through a Special Purpose Vehicle (SPV) to support scientific groundwater mapping, monitoring, and participatory aquifer management involving local communities and stakeholders.
			Ensure convergence with Telangana State Micro Irrigation Project (TSMIP) to promote drip and sprinkler irrigation

			systems for improving water-use efficiency and reducing groundwater extraction pressures.
			Promote crop diversification toward water-efficient crops and cropping systems to reduce irrigation demand, enhance resilience, and improve farm profitability.
			Encourage water-saving rice cultivation practices such as Alternate Wetting and Drying (AWD), direct-seeded rice (DSR), and wet drum seeding in well irrigation commands to enhance water productivity and sustainability.
Agriculture & Horticulture Department			
1	**On-farm Water Management**	Enhance irrigation application efficiency, crop yield, and water productivity through improved field-level water management practices, precision irrigation, and sustainable resource utilization.	Strengthen farmer awareness and capacity building on on-farm water management practices, including land shaping, field layout optimization, and efficient irrigation methods in irrigated farming systems.
			Promote on-farm development interventions such as land consolidation, watercourses, field channels, field drains, land levelling, and shaping to improve water distribution efficiency and reduce conveyance losses.
			Facilitate affordable access to on-farm development services through institutional support mechanisms, custom hiring centres, and service providers to ensure equitable adoption.
			Encourage measurement of irrigation water application using simple field devices, demonstration plots, and skill training programmes to improve irrigation scheduling accuracy.
			Promote soil testing and issuance of soil health cards to support balanced fertilization, site-specific nutrient management, and improved water–nutrient use efficiency.
			Encourage adoption of medium-duration, water-efficient crop varieties and climate-resilient irrigated dry crops/cropping systems to enhance productivity under water-constrained conditions.

			Promote scientific irrigation scheduling based on crop growth stage, soil moisture status, evapotranspiration demand, and appropriate irrigation methods across surface, drip, and sprinkler systems
			Scale water-efficient technologies such as drip irrigation, sprinkler systems, plastic mulching, and precision irrigation approaches through mission-mode institutional mechanisms and special purpose vehicles for commercial and horticultural crops.
2	**Adaptation to Climate Change**	Strengthen the adaptive capacity of farming communities to adopt climate-resilient technologies that enhance water-use efficiency, optimize resource demand, and sustain agricultural productivity under changing climatic conditions.	Promote water-efficient and climate-resilient crops and cropping systems to improve productivity, reduce climate risks, and enhance water-use efficiency in both irrigated and rainfed agriculture.
			Facilitate adoption of climate-resilient agronomic practices including weather-based agro-advisories, soil organic carbon enhancement, crop contingency planning, conservation agriculture (zero/minimum tillage), in-situ moisture conservation, and integrated water harvesting and recycling systems for supplemental irrigation.
			Strengthen climate-informed decision support systems through digital advisory services, capacity building, and extension outreach to enable farmers to effectively respond to climate variability and water scarcity.
3	**Soil Health Management**	Promote balanced fertilization through site-specific nutrient management to enhance crop productivity, improve fertilizer-use efficiency, and sustain long-term soil health.	Strengthen soil testing services and issuance of soil health cards to provide farmers with scientifically validated fertilizer recommendations tailored to crop requirements, soil fertility status, and local agro-ecological conditions
			Promote application of tank silt and organic amendments to improve soil organic carbon, nutrient availability, soil structure, and moisture retention capacity.
			Encourage inclusion of legumes and green manure crops in crop rotations and intercropping systems to enhance biological nitrogen fixation, improve soil fertility, and support sustainable nutrient managemen

4	**Farm Mechanization**	Improve timeliness, precision, and overall efficiency of farm operations to enhance cropping intensity, optimize input use, increase productivity, and promote sustainable agricultural growth.	Promote crop-specific mechanization across the entire agricultural value chain—from land preparation and sowing to harvesting and post-harvest operations—to enhance operational efficiency, reduce labour constraints, and improve productivity.
			Establish and strengthen Custom Hiring Centres (CHCs) to improve access to farm machinery, particularly for small and marginal farmers, thereby ensuring cost-effective mechanization adoption.
			Strengthen training and capacity-building programmes for farmers, rural youth, entrepreneurs, and extension personnel to improve technical skills in operation, maintenance, and efficient utilization of farm machinery.
5	**Improving Agriculture/ Irrigation Extension**	Enhance irrigation advisory services and extension outreach to ensure Water User Associations (WUAs) and farmers have improved access to advanced agronomic practices, efficient water-use technologies, and climate-resilient irrigation solutions.	Promote digital dissemination of irrigated agriculture technologies through mobile applications, decision-support platforms, and ICT-enabled advisory services to provide timely and location-specific guidance to farmers.
			Establish a structured system of regular extension visits by Agriculture Department staff, irrigation experts, and subject specialists to Water User Associations to strengthen field-level technical support and participatory water management.
			Conduct on-farm demonstrations and capacity-building programmes to promote adoption of modern irrigation scheduling tools, including soil moisture sensors, EC and pH meters, mobile advisory apps, automatic weather stations, pan evaporimeters, and rain gauges for improved water-use efficiency and precision irrigation.
Universities			
1	**Characterization of Soil – Plant – Water Relations**	Promote sustainable land and water resource utilization through scientific understanding of soil–plant–water interactions to enhance crop productivity, water-use efficiency, and climate resilience.	Undertake comprehensive soil mapping covering soil texture, soil depth, available water-holding capacity (AWHC), infiltration characteristics, and irrigation water quality to support site-specific land and water management strategies.

			Quantify effective rainfall, atmospheric evaporative demand (ETo), and moisture index across rural districts to improve irrigation planning, water budgeting, and climate-resilient agricultural decision-making.
			Identify water-efficient, climate-resilient crop varieties and cropping systems, including determination of critical irrigation growth stages, moisture stress impacts on yield, effective root-zone depth, and soil moisture extraction patterns to guide field-level water management interventions.
2	**Planning for Efficient Cropping Zones (Cluster-based crop colonies)**	Promote efficient utilization of agricultural resources, inputs, and infrastructure through scientifically planned crop zoning to enhance productivity, optimize resource use, and improve farm incomes	Identify and delineate district-specific cropping zones based on land suitability assessment indices, incorporating soil characteristics, water availability, climate parameters, and socio-economic factors for major field and horticultural crops.
			Promote cluster-based crop colonies to enable efficient input delivery, mechanization, irrigation management, value-chain integration, and market linkages, thereby improving productivity, profitability, and sustainability of agricultural systems.
3	**Crop Water Requirements For Irrigated Dry (ID) Crops**	Optimize water-use efficiency in irrigated dry crops through scientific estimation of crop water requirements to adopt sustainable irrigation management practices and enhance crop yield	Develop crop coefficient (Kc) curves for major field and horticultural crops across agro-climatic zones to support precise irrigation scheduling and improved water-use efficiency.
			Estimate reference evapotranspiration (ETo) for all rural districts using standardized agro-meteorological data to strengthen location-specific irrigation planning and water budgeting.
			Quantify seasonal crop evapotranspiration (ETc), peak crop water demand, effective rainfall, and net and gross irrigation requirements for major agricultural and horticultural crops to enable scientific irrigation scheduling, enhance water productivity, and support climate-resilient crop management.

4	**Water Management in Rice**	Enhance water use efficiency in rice cultivation by minimizing water losses and nitrate leaching through percolation, reducing greenhouse gas emissions, improving irrigation application efficiency, and crop yield under diverse agro-ecological conditions.	Quantify water balance components for alternative rice cultivation methods such as Alternate Wetting and Drying (AWD), direct-seeded rice (DSR), drum seeding, and aerobic rice to assess water productivity, nutrient dynamics, and environmental impacts.
			Develop and promote water-efficient, climate-resilient rice varieties (e.g., Telangana Sona, Kunaram 118) with improved yield stability, reduced water requirements, and adaptability to changing climatic conditions.
			Demonstrate and scale water-saving rice production technologies including drum seeding and direct-seeded rice under canal and tank irrigation commands across diverse agro-climatic zones.
			Promote AWD irrigation practices using field water tubes and aerobic rice cultivation + drip irrigation & sprinkler irrigation under well-irrigated conditions through pilot demonstrations to reduce water consumption, mitigate GHG emissions, and improve water productivity.
5	**Drip Irrigation & Fertigation in Commercial Field (Maize, Sugarcane, Cotton, Red gram & Soybean) and Horticultural (Fruits & Vegetables) and Greenhouse Crops (Well irrigation systems)**	Expand drip irrigation coverage to approximately 13.35 lakh hectares to enhance water and energy-use efficiency, address water and labour scarcity, stabilize groundwater utilization, improve crop yield and quality, increase fertilizer-use efficiency, enhance farm incomes, enable safe use of marginal-quality waters, and promote the supply of quality planting material.	Develop and standardize crop-specific drip irrigation design modules including optimal planting geometry, spacing between driplines and laterals, emitter spacing and discharge rates, number of emitters per plant/tree, and appropriate application rates for major commercial field crops, horticultural crops, and greenhouse production systems.
			Formulate scientific irrigation scheduling protocols based on crop developmental stages, evapotranspiration demand, soil moisture dynamics, wetted area and agro-climatic conditions to optimize water productivity and improve crop performance.
			Develop crop-specific fertigation scheduling guidelines aligned with crop growth stages to enhance nutrient-use efficiency, reduce fertilizer losses, improve soil health, and support sustainable intensification of irrigated agriculture.

6	**Sprinkler Irrigation of Pulses, Millets and Forage Crops Particularly (Light textured soils)**	Expand sprinkler irrigation to approximately 4.5 lakh hectares to improve water-use efficiency, mitigate water scarcity, stabilize groundwater utilization, and enhance crop productivity, quality, water productivity, and farm incomes, particularly in light-textured soils.	Develop crop- and site-specific sprinkler irrigation design modules tailored to different plot sizes, soil types, and agro-climatic conditions to optimize water application efficiency and system performance.
			Prepare scientific irrigation scheduling protocols based on crop growth stages, evapotranspiration demand, and soil moisture dynamics for major pulses, millets, and forage crops to enhance water productivity, reduce irrigation losses, and improve crop yields.
7	**Use of Marginal Quality Water**	Enhance water resource availability and expand irrigated area through the safe and efficient utilization of marginal-quality water, including saline groundwater and treated wastewater, while safeguarding soil health, crop productivity, and environmental sustainability	Assessment and spatial mapping of irrigation water quality in well command areas to characterize salinity, sodicity, nutrient load, and potential contaminants, thereby enabling informed planning for safe agricultural use.
			Develop scientific criteria and management protocols for the utilization of treated wastewater and marginal-quality saline waters in crop production, including guidelines on crop suitability, blending strategies, irrigation scheduling, soil amendments, and monitoring frameworks to minimize risks to soil health, crop safety, and environmental quality
8	**Soil Health Management**	Improve soil organic carbon, macro- and micronutrient status (NPK and trace elements), and soil biological activity to enhance nutrient availability, optimize fertilizer use efficiency, and sustain crop productivity and soil resilience	Characterize desilted tank sediments for nutrient composition, heavy metals, and suitability for agricultural application to support soil fertility enhancement and safe resource recycling.
			Quantify optimal tank silt application rates (t/ha) based on nutrient value of silt, existing soil fertility status, crop nutrient needs, and district-specific agro-ecological conditions to guide scientific nutrient management.
			Promote legume-based crop rotations and green manuring systems to improve soil organic carbon, biological nitrogen fixation, soil structure, and long-term soil health sustainability.
9	**Farm Mechanization**	Enhance timeliness, precision, and operational efficiency of agricultural practices to optimize input	Develop crop- and region-specific mechanization modules covering the entire agricultural value chain—

		use, increase cropping intensity, improve productivity and profitability, reduce drudgery, and contribute to sustainable rural economic growth and livelihood improvement.	from land preparation, sowing, crop management, harvesting, and post-harvest handling—to enhance productivity, resource-use efficiency, and value addition.
			Strengthen capacity building and skill development of farmers, rural youth, entrepreneurs, and extension personnel through structured training programmes on operation, maintenance, and efficient utilization of farm machinery.
			Promote field demonstrations of mechanized crop production systems using appropriate farm equipment tailored to different crops, agro-climatic conditions, and farm sizes to accelerate technology adoption and improve farm efficiency
Special Focus on Rainfed Agriculture for Equitable Development			
1	**Rainfed Agriculture**	Strengthening coping and adaptation mechanisms to stabilize crop yields, enhance farm incomes, and mitigate climate and production risks in rainfed regions	Undertake comprehensive **agro-climatic characterization of mandals and districts** focusing on following parameters to guide location-specific crop planning focusing on: **a)** Climatic water balance parameters including precipitation (P), reference evapotranspiration (ETo), actual evapotranspiration (AET), water surplus (WS), water deficit (WD), moisture index (MI), and climate classification. **b)** Onset and withdrawal patterns of monsoon based on rainfall probability analysis. **c)** Length of Growing Period (LGP) for crop planning. **d)** Identification of drought-prone hotspots. **e)** Selection of diversified crops, cropping systems, and allied enterprises (e.g., dairy, sheep rearing, beekeeping) aligned with LGP. **f)** Development of crop management strategies for deficit moisture conditions.
			Delineate suitable cropping zones for single crop and double cropping systems based on rainfall variability, soil

			moisture availability, and LGP to improve resource use efficiency
			Develop district- and mandal-level crop contingency plans and a climate vulnerability atlas to support evidence-based planning, disaster preparedness, and climate adaptation strategies
			Provide digital agro-meteorological advisory services delivering real-time weather-based guidance on crop management, irrigation scheduling, and risk mitigation.
			Promote rainwater harvesting and farm pond technologies through systematic mapping of potential sites and standardization of designs for supplemental irrigation during dry spells
			Encourage location-specific in-situ moisture conservation practices and climate-resilient agronomic interventions to enhance soil moisture retention and water productivity.
			Establish weather-based pest and disease forewarning systems to minimize climate-related crop losses
			Promote diversified and resilient alternate land-use systems including agri-silviculture, silvi-pastoral, and agri-horticulture and models, particularly in marginal and vulnerable landscapes.
			Support development and dissemination of smallholder-appropriate farm mechanization solutions to improve operational efficiency, timeliness, and resilience in rainfed agriculture.