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**THEMATIC PAPER**

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# **Climate Change Adaptation Measures in Agriculture and Water Sectors in Bundelkhand, Uttar Pradesh: Leveraging Resources**



*Bundelkhand faces severe climate stress driven by erratic rainfall, rising temperatures, groundwater depletion and recurring droughts. Agriculture, largely rainfed, is highly vulnerable due to poor soils, limited irrigation and frequent crop failure. Water resources are under pressure from hard-rock geology, degraded water bodies and increasing demand.*

*Further, women play a central role in Agriculture and Water management but face higher climate risks due to limited access to land, credit, extension services, and decision-making. Climate change—through erratic rainfall, droughts, heat stress, and water scarcity—intensifies women’s workload, health risks, time poverty, and food–nutrition insecurity, especially with rising male out-migration.*

*Under the Climate Adaptation, Resilience and Climate Finance in Rural India (CAFRI II) programme, GIZ is providing technical support to the Directorate of Environment in Uttar Pradesh in implementing Sustainable Agriculture & Jal Jeevan Mission under UP-SAPCC (2021-30). This aligns with the agreed-upon commitment with the MoEFCC to concentrate efforts in Uttar Pradesh on providing technical support to facilitate execution of selected initiatives under the Water & Agriculture Missions of UPSAPCC 2.0, specifically in the Bundelkhand region.*

*Towards this, capacity building of relevant government institutions, as well as the vulnerable ecosystems, which is central to enhancing resilience, was carried out through a range of awareness, capacity development and outreach events in the seven districts of Bundelkhand region. This was aimed at supporting the stakeholders to plan and implement risk informed developmental interventions, as per the mandates of Agriculture and Water Missions of UPSAPCC.*

*This thematic paper examines key climate risks and outlines adaptation measures, based on the capacity building initiatives across Agriculture and the Water sector, including climate-resilient farming, soil and water conservation, livelihood diversification, water budgeting, rainwater harvesting and watershed development. It highlights the need for community-led planning and institutional convergence to strengthen resilience and support sustainable rural development in Bundelkhand.*

# Introduction

The Bundelkhand region is situated in the semi-arid region of Uttar Pradesh and Madhya Pradesh in Central India. In Uttar Pradesh, the region covers the districts of Jhansi, Lalitpur, Jalaun, Banda, Chitrakoot, Hamirpur, and Mahoba. The region's topography is characterised by hard-rock geology, erratic rainfall, and limited groundwater storage. Agriculture is predominantly rainfed, and the majority of farmers (small and marginal farmers) depend on the monsoon. Water scarcity, recurrent drought, land degradation, and socio-economic challenges make Bundelkhand one of the most climate-stressed regions in India.

Climatic variability has put significant stress on Agriculture and Water resources in Bundelkhand. Declining rainfall, increasing temperatures have reduced crop productivity, affected livestock, water availability, and weakened rural livelihoods. Water bodies are drying up, and groundwater levels are falling. Extreme events such as heatwaves, flash floods and intense rainfall episodes are becoming more common.

Adaptation is essential for ensuring stable crop yields, improving water security and reducing climate-induced risks in the region. Addressing these challenges also aligns with the mandates of the District Panchayat Development Plan (DPDP), State Action Plan on Climate Change (SAPCC), and integrated Natural Resource management approaches.



# Climate Change Impacts on Agriculture

Agriculture in the Bundelkhand region is highly sensitive to climate variability due to its semi-arid conditions, fragile ecosystems, and heavy dependence on rainfall. In recent decades, climate change has intensified existing vulnerabilities, affecting crop production, livestock health, and rural livelihoods. The major climate-related stresses influencing Agriculture in the region are outlined below:

## **Erratic rainfall and delayed monsoon:**

These emerging patterns have disrupted traditional cropping calendars. Farmers often face uncertainty in deciding the timing of sowing, which leads to poor germination and uneven crop growth. Delayed or uneven rainfall also increases the risk of crop loss, particularly for rainfed crops.

## **Rising temperatures:**

It has a direct negative impact on both crops and livestock. Heat stress reduces crop yields by affecting flowering and grain formation, while higher temperatures increase evapotranspiration, leading to greater water stress. Livestock productivity is also affected due to reduced feed availability and increased incidence of heat-related diseases.

## **Frequent and prolonged droughts:**

The frequent drought conditions reduce soil moisture levels and limit natural groundwater recharge, making water scarce during critical agricultural seasons.

## **Soil degradation:**

The low Organic Carbon and poor structure reduce the soil's ability to retain moisture and nutrients. The aforementioned climate-induced stresses accelerate erosion and nutrient loss, resulting in declining agricultural productivity.

## **Limited irrigation infrastructure**

increases the region's dependence on rainfed agriculture. Inadequate access to canals, tanks, and groundwater sources restricts farmers' ability to manage water during dry periods, making agriculture highly vulnerable to rainfall variability.

The combined effect of these climate stresses results in a high risk of crop failure. This directly threatens food security, reduces farm incomes, and weakens household resilience. Repeated losses also push small and marginal farmers into debt and increase livelihood insecurity.

These pressures make the Agriculture sector highly sensitive to climatic shocks and require robust adaptation measures.

# Climate Change Impacts on Water Resources

Water resources in the Bundelkhand region are under severe stress due to recurring droughts, variable rainfall, and rising temperatures. Climate change has intensified both water scarcity and extreme events, affecting the availability, distribution, and sustainability of surface and groundwater resources. The major climate-related stress factors influencing water resources in the region are outlined below:

## **Declining rainfall combined with high evapotranspiration:**

This reduces the availability of surface water in rivers, ponds, and reservoirs. Higher temperatures increase water loss, resulting in less water available for domestic and agricultural use.

## **Hard-rock aquifers:**

Such Presence restricts natural groundwater recharge. As a result, excessive extraction leads to rapid depletion of groundwater levels, especially during prolonged dry periods.

## **Silted and encroached water bodies:**

Many traditional water bodies such as Ponds, Tanks, and Talabs, have become silted or encroached upon. This reduces their storage capacity and limits their role in groundwater recharge and drought mitigation.

## **Increasing water demand:**

Increasing demand for water from households, agriculture, and livestock has intensified competition among different users. During drought years, this competition often leads to conflicts and unequal access to water.

## **Large dependency on groundwater:**

Limited canal irrigation and inadequate surface water sources have increased dependence on groundwater. This over-reliance further accelerates groundwater depletion and undermines long-term water security.

Recent phenomena of Extreme rainfall events also lead to flash floods and soil erosion, while long dry spells deepen water shortages.

## Key Adaptation Measures in Agriculture

The Agriculture system of Bundelkhand is highly vulnerable to climate variability due to its semi-arid ecology, recurrent droughts, and dependence on rainfed farming. Strengthening adaptive capacity

requires a combination of farm-level technological interventions, institutional support, and livelihood diversification. The following adaptation measures focus on improving resilience, sustaining productivity, and leveraging existing Government of Uttar Pradesh schemes for capacity building and financial support.

## Climate-Resilient Agriculture:

Climate-resilient agriculture promotes efficient use of natural resources through improved crop and livestock systems suited to local climatic risks. It emphasizes better water and nutrient management, adoption of drought- and heat-tolerant crop varieties, crop rotation, soil health management, and precision input use to reduce crop failure during prolonged dry spells.

In Uttar Pradesh, capacity building and financial support for climate-resilient practices can be leveraged through the **UP Krishi Vikas Yojana**, **Rashtriya Krishi Vikas Yojana (State Component)**, and the **State Millet Mission**, which promotes hardy crops suitable for Bundelkhand. The **Pradhan Mantri Krishi Sinchayee Yojana** is implemented through the state for micro-irrigation and farm water efficiency, while training and demonstrations are supported by **Krishi Vigyan Kendras (KVKs)** and the **Department of Agriculture, Uttar Pradesh**.

### 1. Low-Chemical Input Farming for Enhancing Soil Productivity

The utilisation of organic manure, biofertilizers, and biopesticides enhances soil fertility and water-holding capacity. It not only increases the carbon content in the soil but also reduces the industrial greenhouse gas emissions by restricting the usage of chemical fertilisers-prepared by burning fossil fuels. At the same time, it enhances the porosity and soil moisture retention in the soil, reducing the demand of frequent irrigation.

This approach is supported in Uttar Pradesh through **Paramparagat Krishi Vikas Yojana (PKVY)** for organic and natural farming, the **Bhartiya Prakritik Krishi Paddhati (BPKP)**, and State-level initiatives promoting vermicomposting and bio-input units. Farmer training and cluster-based implementation are facilitated by the **UP Department of Agriculture** and **KVKs**.



### 2. Soil Moisture and Land Management

Mulching, crop residue retention, application of farmyard manure, and crop rotations with legumes help maintain soil fertility and retain moisture for longer periods. Contour farming and farm bunding in undulating terrain reduce runoff and increase infiltration, giving crops more moisture during dry spells.

Financial and technical support for these measures can be accessed through **PMKSY-Watershed Development Component (WDC)** implemented by Uttar Pradesh, **Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGA)** (now known as Viksit Bharat-Guarantee for Rozgar and Ajeevika Mission (Gramin) (VB-G RAM G) for land treatment works, and the **UP- Watershed Development Programme**, which supports soil and moisture conservation activities at the landscape level.



### 3. Improved Farm Water Management

Small farm Ponds, Check Dams, Percolation Tanks, and renovated Talabs provide supplemental irrigation when monsoon rains fail, recharge shallow aquifers and reduce drought stress more effectively. Micro-irrigation systems such as Drip and sprinkler irrigation increase water use efficiency, especially in fruit orchards.

In Uttar Pradesh, these interventions are supported through **PMKSY–Har Khet Ko Pani (HKKP)**, **PMKSY–Per Drop More Crop (PDMC)**, and convergence with **MGNREGA** for water harvesting structures. The **UP Jal Shakti Department** and **Minor Irrigation Department** play a key role in planning and execution



### 4. Climate-Smart Horticulture and Agroforestry

Drought-tolerant fruit species—such as Aawala (Indian gooseberry), Ber (Indian jujube), Guava, Lemon, and Drumstick—perform well under limited irrigation. Agroforestry models combining hardy trees with millets or pulses improve soil structure, reduce heat stress and diversify income sources from fruits, fuelwood, and fodder.

Support for these practices is available through the **UP-Horticulture Mission, National Horticulture Mission (State Implementation)**, and the **UP-Agroforestry Policy**, which promotes tree-based farming systems. Nursery development, planting material, and training are provided through state horticulture departments.



### 5. Diversified Rural Livelihoods

Livelihood diversification - Goat rearing, Dairy activities, Poultry, and small-scale Fisheries in rehabilitated Tanks reduces dependence on climate-sensitive agriculture. Kitchen gardens using limited water improve household nutrition, especially during drought periods.

In Uttar Pradesh, financial and skill support can be accessed through **National Livestock Mission (State Component)**, **UP Dairy Development Programmes, Fisheries Development Schemes, NRLM–UPSRLM**, and **MGNREGA** for asset creation. Kitchen gardens are promoted through **Poshan Abhiyan** and Horticulture Extension services.



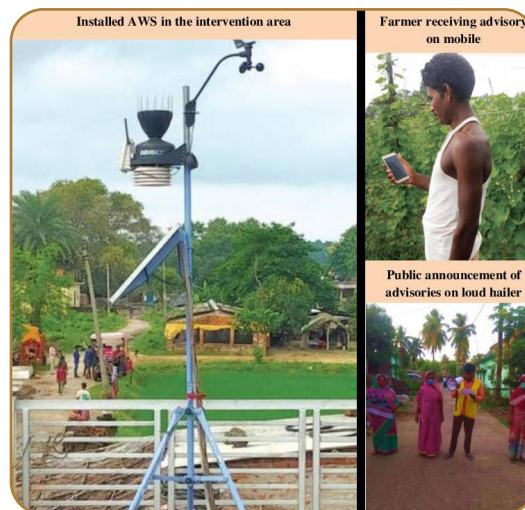
## 6. Use of Climate Information Services

Weather advisories from KVKs, IMD, and District Agro-Met Units help farmers to make timely decisions on sowing, irrigation and pest management. These services reduce losses during delayed monsoons or extreme temperatures.

In Uttar Pradesh, **Agromet Advisory Services** are delivered through **IMD, KVKs**, and **District Agrometeorological Units**, supported by the State Agriculture Department. Digital platforms, SMS alerts, and village-level extension networks strengthen last-mile dissemination.

## 7. Gender-Responsive Actions in Agriculture

Gender-responsive adaptation recognizes women as farmers, water managers, and decision-makers. Promoting drought-tolerant crops, mixed farming systems, women-focused extension, access to quality seeds, climate advisories in local language, and drudgery-reducing tools enhances women's adaptive capacity. These actions are supported through **UP State Rural Livelihood Mission (UPSRLM)**, **Mahila Kisan Sashaktikaran Pariyojana (MKSP)**, and women-focused components under agriculture and horticulture schemes. Custom hiring centres and women SHGs serve as key institutional platforms for implementation.



# Adaptation Measures in the Water Sector

Erratic rainfall, hard-rock geology, declining groundwater levels, and weak surface water systems shape water scarcity in Bundelkhand. Climate change has further intensified drought frequency and water stress. Strengthening water security, therefore, requires locally planned, climate-informed, and institutionally supported adaptation measures, with strong convergence of existing government programmes at the village, Block, and District levels.

## 1. Water Budgeting

Water budgeting helps communities assess annual water availability and plan its use. It identifies supply-demand gaps to support decisions on crop choice, groundwater extraction and domestic water allocation. Integrating water budgeting into the **GPDP** processes strengthens local water governance. Capacity building and planning support can be leveraged through **Jal Jeevan Mission, Atal Bhujal Yojana (ABHY)**, and technical guidance from the **UP Jal Shakti Department** and **CGWB**

## 2. Farm Ponds through MGNREGA

Farm ponds capture monsoon runoff and support protective irrigation during dry spells. They improve groundwater recharge, reduce soil erosion and create employment for poor and marginalised households under MGNREGA. Village-level planning ensures proper site selection and community involvement. These activities are directly supported under **MGNREGA**, with technical convergence from **PMKSY** and planning support through Gram Panchayats and Block-level institutions in Uttar Pradesh.



## 3. Rainwater Harvesting Systems

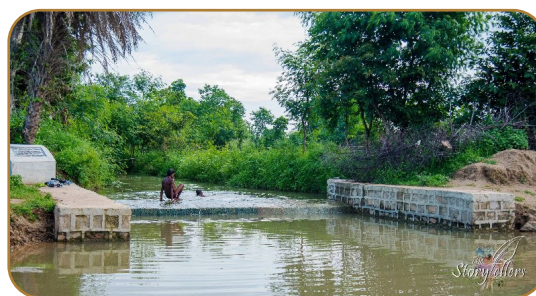
Rooftops and surface rainwater harvesting support domestic needs and enhance groundwater recharge. These decentralised systems are essential where ground levels continue to decline. Financial and technical support is available through **Jal Jeevan Mission, Swachh Bharat Mission (Gramin)**, and State schemes implemented by the **UP Jal Nigam** and Panchayati Raj Institutions.

## 4. Restoration of Traditional Water Bodies

Reviving Ponds, Johads, Dibri and Stepwells improves local water security and groundwater recharge. Desilting, catchment protection, and repairing feeder channels extend the life of these systems and strengthen resilience during drought. Desilting and repair works can be financed through **MGNREGA, Amrit Sarovar Mission**, and State-level Pond Rejuvenation programmes led by the **UP Rural Development Department**.

## 5. Integrated Watershed Management

Integrated Watershed Management (IWM) – contour trenches, check dams, gully plugs, and farm bunding reduce runoff, enhance infiltration, and rehabilitate degraded land. . These interventions are supported through **PMKSY–Watershed Development Component, MGNREGA**, and **Rashtriya Krishi Vikas Yojana**, with implementation support from State Watershed agencies.



## 6. Expansion of Water-Efficient Infrastructure

Farm Ponds, Percolation Tanks, recharge Pits, and Anicuts increase capture of limited monsoon rainfall. Integrating these structures with micro irrigation and crop planning enhances long-term water availability. These structures can be supported through **PMKSY, MGNREGA**, and the **UP Minor Irrigation Department**, with convergence toward micro-irrigation systems.

## 7. Use of Climate and Hydrological Information Services

Seasonal forecasts, rainfall monitoring and drought alerts support early action and informed planning. Linking district-level water planning with IMD, CGWB, and State Disaster Management advisories enables proactive water governance. Capacity building can be strengthened through linkages with **IMD, CGWB, State Disaster Management Authority**, and District-level Agro-Met and Water Resource Units.

## 8. Gender-Responsive Actions in Water Resources

These measures concern water resources adaptation, where women's participation is critical for sustainability and equity. Strengthening and repairing traditional water-harvesting structures (Talabs, Johads, Check Dams, and Farm Ponds), promoting in-situ moisture conservation (such as contour bunding, mulching, and field trenches), and improving groundwater recharge are key in Bundelkhand's hard-rock hydrogeology. These interventions become more effective when women are included in planning and governance—through representation in water user groups, village water and sanitation committees, and watershed institutions—so that priorities like drinking water reliability, equitable distribution, and maintenance are addressed. Linking livelihood programmes and public works (e.g., SHG platforms and rural employment schemes) to climate-resilient water works can create assets while ensuring women's wages and safety. Gender-responsive actions can be supported through **UP State Rural Livelihood Mission (UPSRLM)**, **MGNREGA**, and **Jal Jeevan Mission**, by linking SHGs and village Water Committees with climate-resilient water works and livelihood generation.

## Conclusion

Bundelkhand faces severe climatic stress due to erratic rainfall, recurrent droughts, land degradation, and groundwater depletion. Strengthening resilience in this semi-arid region requires coordinated action Agriculture and Water sectors. Climate-resilient agriculture, improved soil and water management, agroforestry, and diversified livelihoods—can reduce exposure to climatic shocks and stabilise farm incomes. Simultaneously, robust water-sector interventions such as water budgeting, restoration of traditional water bodies, watershed development, farm ponds, rainwater harvesting, and climate information services are essential to ensure long-term water security.

Effective adaptation in Bundelkhand depends on strong local institutions, particularly Panchayati Raj Institutions, and is guided by frameworks such as the GPDP, DPDP, and SAPCC. Convergence of schemes like MGNREGA, Watershed programmes, and Horticulture Missions further strengthens the adaptive capacity of rural communities. Together, these measures offer a pathway to reduce climate vulnerability, enhance natural resource sustainability, and support resilient rural development in Bundelkhand.

