

Ecosystem Restoration through Landscape Resource Conservation: Lessons Learned from Central India

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Summary

This policy brief highlights the outcomes and lessons learned from a landscape restoration initiative focused on dryland management in Central India's Bundelkhand region. Through integrated and participatory resource management, anchored in the restoration of traditional rainwater harvesting systems and scientific monitoring, the project achieved significant improvements in groundwater recharge, cropping intensity, and rural livelihoods. A key innovation was the revival of the traditional haveli system, which had fallen into disrepair. Introducing an innovative masonry core wall concept and safe water discharge outlets, the restored havelis not only enhanced groundwater recharge but also strengthened a range of ecosystem services and supported productive post-monsoon agriculture, revitalizing previously abandoned lands. The Bundelkhand experience demonstrates that science-

based, community-driven approaches can address the major challenges of land degradation, water scarcity, and rural poverty in India's dryland regions. The project calls for scaling similar models nationwide through coordinated, dedicated-funding, and evidence-driven policies. Such efforts would advance the country's goals for climate adaptation, land degradation neutrality, water security, and rural prosperity.



The Context

The Bundelkhand region of Central India, covering parts of Uttar Pradesh and Madhya Pradesh, is grappling with a convergence of ecological and socio-economic crises. Its landscape is inherently fragile, marked by poor water retention capacity, shallow and low-fertile soils, and highly erratic rainfall patterns. These natural constraints have been severely exacerbated by unsustainable land use practices, deforestation, overgrazing, and the cumulative impacts of climate variability. Over the last five decades, the region has witnessed a significant decline in annual rainfall, by nearly 250 mm, along with frequent droughts and extreme temperature fluctuations, severely affecting the agricultural calendar and groundwater recharge processes (Singh *et al.*, 2014; Garg *et al.*, 2020).

A major manifestation of these stressors is the extensive degradation of land. Nearly 30% of Bundelkhand's productive agricultural land has been left fallow either during kharif or rabi seasons due to declining soil fertility, erosion, and poor management practices (Padhan *et al.*, 2025). Reduced organic matter, and nutrient depletion have rendered large areas not suitable for cultivation (Sahu *et al.*, 2015). Simultaneously, the region's overdependence on groundwater for irrigation, in the absence of sufficient surface water infrastructure or rainwater harvesting systems, has led to alarming groundwater depletion (Singh *et al.*, 2019; Singh *et al.*, 2022). Seasonal water scarcity has become chronic, especially during the dry summer months, forcing women and children to travel long distances in search of drinking water and domestic supplies, thereby increasing household drudgery and vulnerability.

These ecological challenges have translated into a sharp socio-economic decline. Over 80% of Bundelkhand's population lives below the poverty line, with a high dependency on rainfed agriculture and livestock for livelihoods (NITI Aayog, 2016). Low cropping intensity, often no more than 110%, and poor land and water productivity have driven widespread food insecurity and malnutrition (Shakeel *et al.* 2012). Consequently, distress migration to urban centers is widespread, leaving behind elderly family members and children, and further weakening the rural workforce and social system.

Building on the substantial public investments made through programs like the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), the Integrated Watershed Management Programme (IWMP), and the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), there remains significant scope to further enhance outcomes. Many interventions to date

have focused on the individual farm level, presenting an opportunity to integrate larger ecological processes at the landscape scale. Strengthening attention to upstream–downstream hydrological linkages, soil–water–vegetation interactions, and ridge-to-valley connectivity can help create more cohesive and sustainable outcomes (Anantha *et al.*, 2022). Strengthening the alignment between development schemes and scientific evidence presents an important opportunity to maximize impact (Azhoni *et al.*, 2017).

To address these challenges, ICRISAT adopts an integrated and scalable solutions rooted in landscape-level planning and ecosystem restoration to build system resilience by following agroecological principles. This approach supports building groundwater resilience, moisture retention ability, improving baseflow and cropping intensification with carbon neutrality. By treating land, water, and vegetation as interconnected resources, landscape management approach helps build climate resilience, enhance productivity, and restore ecosystem functions. This policy brief documents lessons learned from dryland management efforts in Central India which can inform policy frameworks and support the design of replicable models for other vulnerable agro-ecological regions.

Landscape Restoration in Bundelkhand: A Multi-Pronged Strategy

Between 2018 and 2022, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and its consortium partners, with support from the Government of Uttar Pradesh, undertook a comprehensive landscape-scale restoration initiative in the Bundelkhand region of Uttar Pradesh. This effort spanned 22 villages across seven districts, covering an extensive area of 35,000 hectares (Figure 1). The interventions were designed to address the multifaceted challenges of land degradation, water scarcity, low productivity, and rural distress by integrating science-based natural resource management with community-centric approaches.

A central component of the intervention was Integrated Landscape resource conservation, implemented through a combination of in-situ and ex-situ practices (Figure 2). In-situ measures such as field bunding and construction of field drainage structures were carried out primarily in upland areas to reduce runoff velocity, enhance soil moisture retention, and prevent erosion. Complementing these were ex-situ structures like check dams, community ponds, and the rejuvenation of

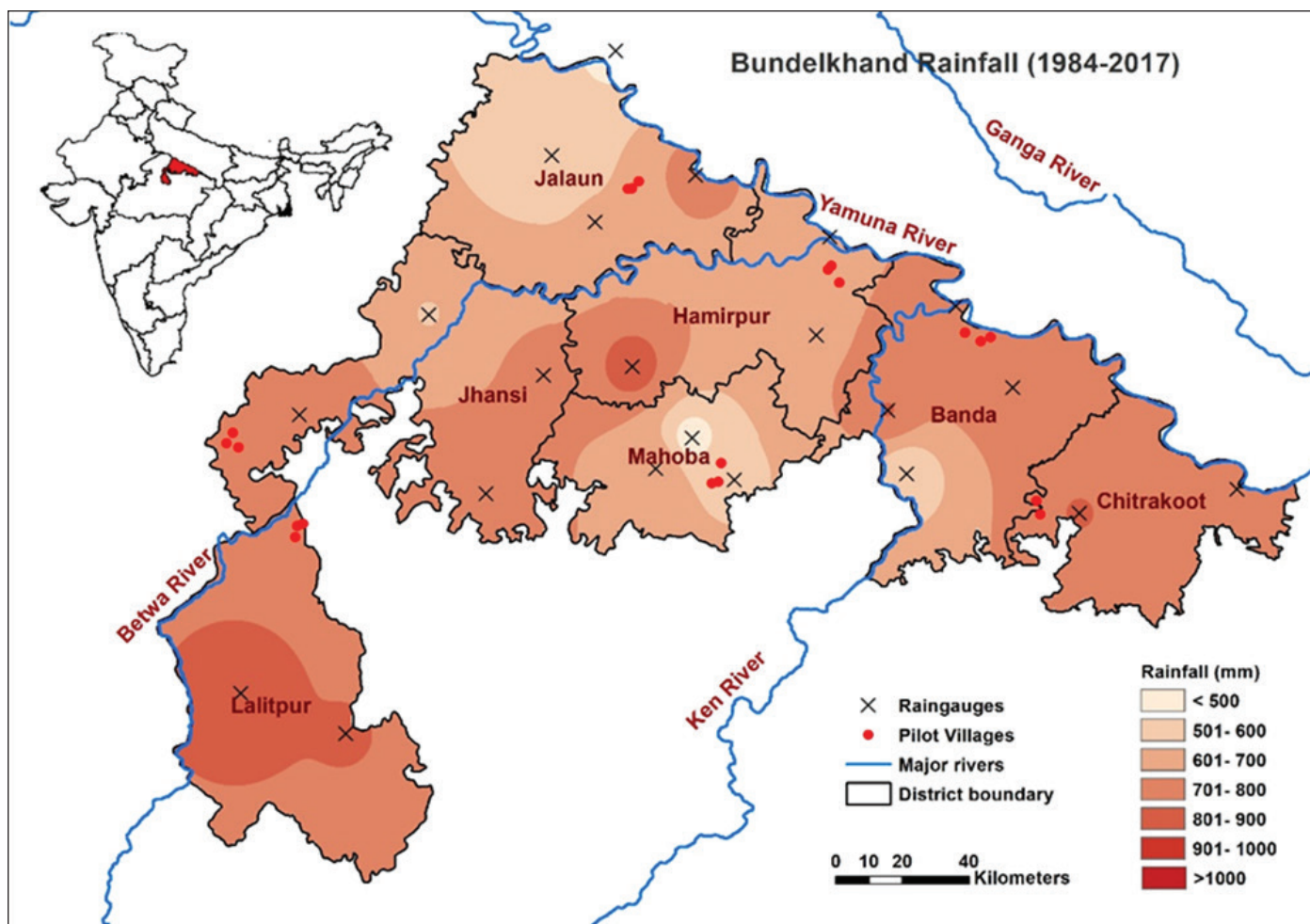


Figure 1: Project Locations Across 7 Districts in the Bundelkhand Region.

traditional water harvesting systems in different parts of the landscape following decentralized approach. These interventions worked in tandem to capture rainwater, increase surface storage, and improve groundwater recharge across the entire watershed.

A unique and culturally resonant aspect of the initiative was the revival of the traditional *haveli* system, an indigenous rainwater harvesting method once widely practiced in Bundelkhand region. These *havelis*, which had become defunct due to neglect and structural decay, were restored using an innovative masonry core wall design that strengthened the earthen embankments and prevented breaches during heavy rains. Additionally, masonry outlets were constructed to safely discharge excess water. This revival enabled the dual benefit of groundwater recharge and enhanced post-monsoon cultivation, bringing back productivity to once abandoned lands.

To complement hydrological interventions and promote ecological stability, large-scale agroforestry and biological measures were undertaken. A total of 0.35 million trees, including species like Teak (*Tectona grandis*), Malabar Neem (*Melia dubia*), ber (*Ziziphus mauritiana*), lemon (*Citrus limon*), guava (*Psidium*

guajava) and various fruit trees along with *Acacia Senegal*, were planted to stabilize slopes, reduce surface runoff, improve microclimates, and enhance biodiversity. These vegetative barriers not only helped reduce erosion but also contributed to long-term improvements in soil fertility, carbon sequestration, and income diversification.

Recognizing the importance of scientific validation and adaptive management, a state-of-the-art hydrological monitoring system was established across multiple sites. This included tools to measure surface runoff, groundwater table fluctuations, and baseflow contributions, enabling real-time assessment of the impact of interventions on water resources. These insights informed adaptive planning, ensuring that interventions were data-driven and locally appropriate.

Alongside resource conservation, a strong emphasis was placed on livelihood enhancement through climate-smart agricultural technologies. This included laser land levelling to improve water-use efficiency and reduce irrigation demand, introduction of high-yielding and drought-tolerant seed varieties, and promotion of balanced nutrient management to close yield gaps. Interventions in livestock and fodder development, such

Field bunding

Laser Land Leveling

In-situ Interventions

Field Drainage Structures

Zero Tillage

Livestock

Field Crops

Production System

Agroforest

Horticulture Crops

Yield Monitoring

Runoff Gauging

Scientific Data Monitoring

Moisture Monitoring

Automatic Weather Station

In-situ Interventions

Checkdams

Farm/Community Ponds

Deepening & Widening
Stream Network

Haveli Rejuvenation

Diversion Drains

Figure 2: Transformative Interventions implemented in Bundelkhand.

as improved breeds of cow and buffalo using Artificial Insemination, fodder crops, and better veterinary care, helped increase milk production and reduce seasonal fodder shortages. Together, these activities contributed to enhanced cropping intensity, reduced fallow land, and increased farm incomes.

This integrated suite of interventions, anchored in watershed hydrology, traditional knowledge, modern agronomy, and local participation, demonstrated a replicable model for landscape restoration in dryland contexts. The Bundelkhand experience highlights how synergistic action across water, land, vegetation, and livelihoods can transform degraded regions into resilient and productive agro ecosystems.

Evidence of Transformation at Scale

The integrated landscape restoration initiative implemented in Bundelkhand between 2018 and 2022 has delivered a range of significant and measurable outcomes across hydrological, agricultural, and socio-economic dimensions. These outcomes not only demonstrate the effectiveness of landscape-based approaches in dryland regions but also provide compelling evidence to inform future policy and investment strategies.

One of the most striking outcomes was the creation of an additional 6 Million Cubic Meters (MCM) of water storage capacity through a combination of traditional haveli restoration, check dams, ponds, and deepening of stream network. This enhanced capacity has enabled

the recharge of approximately 15 MCM of groundwater annually, revitalizing groundwater aquifers that had long been depleted. As a result, groundwater levels in dug wells rose by 4 to 10 meters, making water available for critical irrigation during dry spells and improving access to drinking water in many villages.

The interventions also had a strong ecological impact. Baseflow in streams and rivers increased by 30 to 50%, reflecting a healthier hydrological regime and more sustained water availability during the post-monsoon and winter seasons. Additionally, the structural and biological measures, including agroforestry and field bunding, led to a 70 to 80% reduction in soil erosion. This helped stabilize the landscape, preserve soil fertility, and reduce sedimentation in water bodies, thereby extending the functional life of the water harvesting structures.

The availability of moisture and groundwater, combined with climate-smart farming practices, translated into substantial agricultural gains. Cropping intensity increased from 110% to 180%, as previously fallow land was brought back under cultivation. Nearly 1200 ha of unproductive permanent fallow land and 12000 ha of seasonal fallow land, due to water scarcity and poor soil conditions, were successfully reclaimed and converted into productive fields. This expanded area under cultivation provided farmers with new opportunities for crop diversification with high value crops such as groundnut and double cropping, particularly during the rabi season.

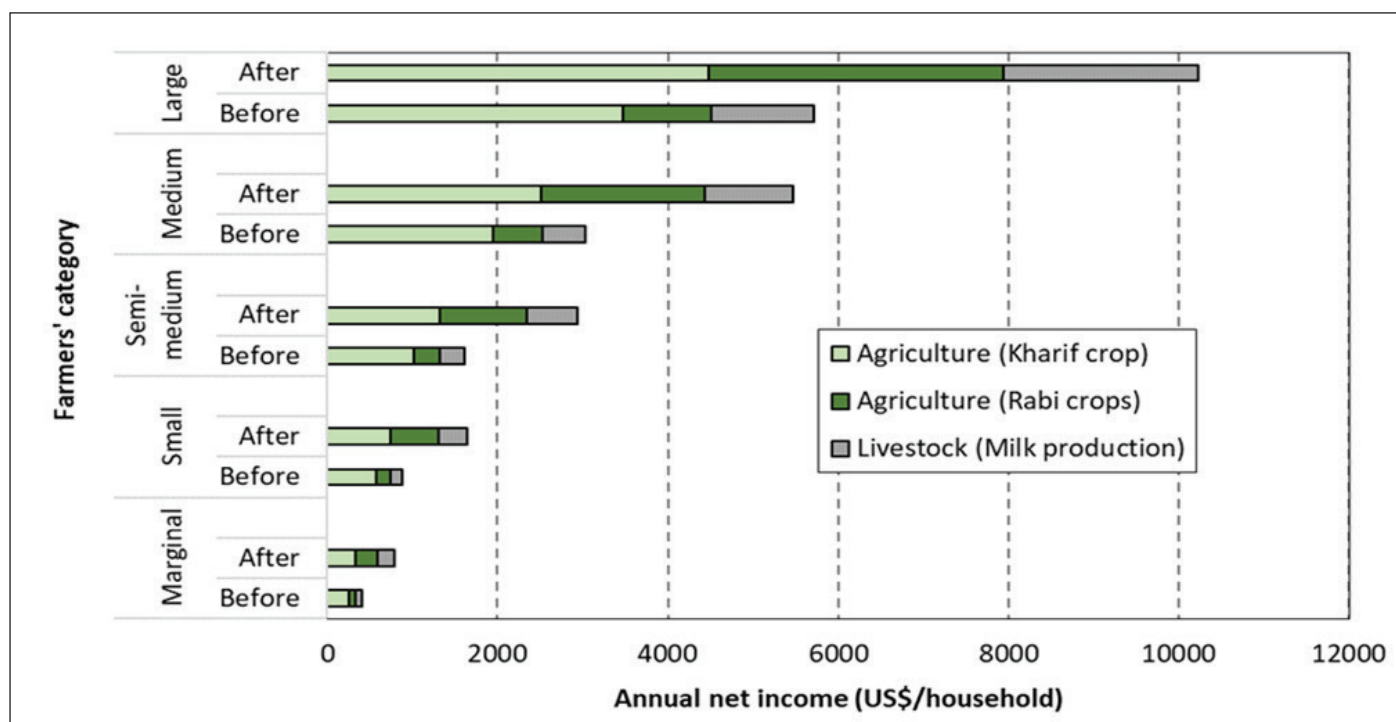


Figure 3: Impact of landscape resource conservation on household income in Bundelkhand region, Uttar Pradesh, India.

Farmers experienced significant increases in productivity and yields, owing to improved land and water management, better crop varieties, and targeted agronomic practices. For instance, the average chickpea yield rose from 800 kg/ha to 1,800 kg/ha, more than doubling productivity and ensuring better market returns. Similar yield improvements were recorded for field pea and mustard as well, supported by demonstrations of balanced nutrient application and improved soil moisture retention.

Perhaps the most significant indicator of success was the substantial improvement in household income. Figure 3 illustrates the changes in annual net income from agriculture and livestock across different household categories before and after landscape interventions. Net income varied significantly by landholding size, with benefits largely proportional to farm size. While kharif season income showed a modest rise (~30%), rabi season income increased substantially (>200%) due to improved water availability. Additionally,

better rabi cropping and fodder access boosted milk production income by 90–200% across farmer categories. Overall, annual net income per household rose by US\$ 385 for marginal, US\$ 770 for small, US\$ 1,330 for semi-medium, US\$ 2,435 for medium, and US\$ 4,520 for large farmers. This increase was driven by enhanced agricultural returns, reduced input costs (due to efficient water and nutrient use), and diversified sources of income including agroforestry, fodder production, and livestock rearing. The improved economic stability also played a key role in reversing distress migration, with many families choosing to remain in their villages and invest in agriculture as a viable livelihood opportunity. These outcomes collectively highlight how a coordinated, science-led, and community-anchored approach to landscape restoration can transform degraded regions into resilient, productive, and economically viable agro-ecosystems, offering a blueprint for replication in other dryland areas of India and beyond.

Transformative Impacts



Soil and Water Conservation

Structural and biological measures, including agroforestry and field to **80% reduction** in soil erosion

Groundwater levels in dug wells rose by **2 to 5 meters**, making water available for critical irrigation during critical access to drinking water in many villages.

About **2.5 MCM of storage capacity** is created to harvest minimum **6 MCM surface runoff** which facilitated groundwater recharge.

Enhanced baseflow flow by **30% to 50%**



Agricultural Productivity

Improved land and water management, better crop varieties, and targeted helped to enhance chickpea yield from **800 kg to 1800 kg per ha.**

Enhanced land and water use efficiency by converting about **2700 acres of permanent fallow** land and **5000 acres of seasonal fallow** land into productive cultivation.

Increased crop intensification from **110% to 180% with improved resource management.**



Livelihood and Community Benefits

About **10,000 farmers benefited** with reduced risk crop failure by enhancing moisture availability.

Fodder availability has improved from deficit (50>/o deficit level) to surplus

Enhanced income of farmers from **40% to 140%** compared to baseline status

Reduced cost of cultivation by **Rs.12000-15000 per ha** with increased groundwater availability and reduction of requirements.

A network **20 km approach roads** to agricultural fields developed to improve access



Resource use Efficiency

Enhanced well recovery period from **50-100 hrs to 10-15 hrs** with groundwater availability.

Enhanced land and water use efficiency

Improved groundwater availability for domestic use reduced drudgery particularly of women and children

Enhanced capacity and awareness of farming community on best management practices

Key Lessons Learned from Landscape Restoration in Bundelkhand

The multi-year, multi-stakeholder experience of implementing landscape-based resource conservation and restoration in Bundelkhand has yielded several valuable insights that are directly relevant for shaping future policy and programmatic actions across similar dryland regions. These lessons highlight the importance of integration across scales, sectors, and stakeholders for achieving lasting impacts.

Participatory Scientific Planning is Fundamental for Success

A key feature of the initiative was the integration of farmers' knowledge with scientific innovations, enabling a more precise alignment of interventions with local challenges, topography, and land-use patterns. This co-creation of solutions bridged the gap between traditional practices and modern science, resulting in more effective and adaptable strategies. The active involvement of village committees, user groups, and line department personnel further strengthened accountability, equity, and transparency in resource allocation and monitoring. Besides, the strongest outcome of the initiative was the involving local communities, farmers, and village-level institutions from the outset in the planning, design, and execution of interventions which fostered a strong sense of ownership. This participatory approach ensured that interventions were contextually appropriate, socially acceptable, and locally maintained. Participation in decision-making not only increased community stewardship of created assets but also contributed to conflict resolution and consensus-building among stakeholders.

Scale effect: Integration of Engineering and Biological Interventions from Plot to Watershed Scale

Conventional development efforts often concentrate on individual farms or households, limiting the scope and longevity of their impact. The Bundelkhand experience demonstrated that effective restoration must be planned and executed at the landscape or watershed scale to account for the interdependencies among soil, water, and vegetation systems. For instance, interventions focused solely on downstream agricultural fields, without addressing degraded uplands and ridgelines, resulting in rapid siltation, increased runoff, and only short-term gains. In contrast, the initiative adopted a ridge-to-valley approach, integrating both in-situ and ex-situ measures across the watershed. This

holistic strategy maintained hydrological continuity, reduced soil erosion, and stabilized entire micro-watersheds. By combining structural interventions such as masonry and earthen works with biological measures like agroforestry, the initiative enhanced the resilience and sustainability of the landscape. This multi-scale integration produced system-wide benefits, including improved groundwater recharge, rejuvenation of baseflows, and a significant reduction in drought and flood risks.

Linking Conservation with Livelihoods Enhances Sustainability

The sustainability of natural resource management practices hinges on their alignment with the livelihood priorities of rural communities. The initiative demonstrated that when conservation practices (e.g., bunding, afforestation, water harvesting) are bundled with income-generating interventions such as improved seeds, livestock development, fodder production, and agroforestry, adoption rates are significantly higher. Farmers are more willing to invest time and labor in maintaining structures or adopting soil-health practices when they see tangible returns. In this context, the project showed how agriculture intensification and diversification, enabled by improved water and soil resources, could drive poverty reduction, food security, and reduced migration.

Science-based Planning and Convergence Enhance Efficiency and Impact

A critical lesson was the value of integrating scientific tools, data, and diagnostics into planning and implementation. The use of land resource inventories (LRI), hydrological assessments, slope analysis, and water budgeting ensured that interventions were not only technically sound but also economically optimized. For instance, understanding land slope and landform dynamics helped in placing water harvesting structures where they would harvest and contribute to yield maximum recharge with minimum investment. Additionally, the convergence of technical expertise, government schemes (e.g., MGNREGS, PMKSY), and community participation created a multiplier effect, combining public investments with scientific guidance to achieve system-level outcomes. Convergence and collaboration are essential to maximize returns and scale impact. Together, these lessons affirm that landscape restoration is not just a technical challenge, but it is a socio-ecological and institutional challenge. Addressing it requires working with people, across geographies and departments, grounded in science and driven by a shared vision of resilience and sustainability.

Policy Implications and Recommendations

The Bundelkhand landscape restoration initiative demonstrates that integrated, science-based, and community-driven approaches can effectively address the intersecting challenges of land degradation, water scarcity, and rural poverty in dryland regions. To build on this success and mainstream such approaches across similar agro-ecological zones, the following policy recommendations are proposed:

Institutionalize Integrated Landscape Planning

There is an urgent need to shift from fragmented, plot-level interventions to watershed-scale planning that considers the entire landscape, from ridge to valley, as a unit of development. This requires institutionalizing the use of scientific tools such as integration of Land Resource Inventory and hydrology, digital tools at the block and district levels. These tools can help in the i) landscape characterization; ii) resource quantification; iii) demand-supply gap assessment and iv) prioritization of interventions. Further, this approach can help optimize resource allocation and guide the design of context-specific strategies for water retention, soil conservation, and vegetation management. State and district planning bodies should formally adopt landscape-based planning frameworks in rural development programs and schemes to maximise the benefits.

Mainstream Nature-Based Solutions in Development Programs

To enhance ecological sustainability and climate resilience, Nature-based solutions (NbS) such as agroforestry, decentralized rainwater harvesting, and soil moisture conservation must be embedded into large-scale rural development missions. Programs like MGNREGS and PMKSY offer powerful platforms for scaling NbS by combining employment generation with ecological restoration. Guidelines should be updated to explicitly promote ecosystem-based interventions, including traditional water harvesting systems such as haveli rejuvenation, field bunding with surplus arrangements and stream rejuvenation by deepening and widening with technical backstopping from research institutions.

Foster Convergence and Multi-Stakeholder Partnerships

One of the key enablers of success in Bundelkhand was the convergence of efforts across government departments, research institutions and community-based organizations. To replicate this, formal mechanisms for institutional convergence and inter-departmental coordination must be established at the district and state

levels. Joint planning cells or convergence committees can be created to align objectives, pool resources, and ensure complementary action across schemes. Incentivizing cross-sectoral collaboration and providing performance-based grants for integrated outcomes can further encourage holistic approaches.

Incentivize Ecosystem Services and Landscape Stewardship

To sustain conservation practices and encourage long-term landscape stewardship, there is a need to incentivize ecosystem services provided by communities. This includes mechanisms for carbon credits, water credits, biodiversity offsets, and payments for ecosystem services. Policy frameworks should be developed to quantify, certify, and remunerate communities for ecosystem benefits such as carbon sequestration from agroforestry, enhanced groundwater recharge, and erosion control. Piloting and scaling such market-linked incentive models can unlock new financing for restoration.

Invest in Monitoring, Data Systems, and R&D

Robust monitoring and evaluation systems are essential to track the biophysical and socio-ecological and economic impacts of landscape interventions over time. Investment is needed in real-time hydrological monitoring, digital and AI tools, and community-based tracking systems to assess runoff, groundwater levels, soil erosion, and land use changes. Additionally, continued support for research and development is critical to innovate and refine interventions, such as low-cost water harvesting designs, drought-tolerant crops, and digital advisory systems. Adaptive management based on scientific data ensures that restoration approaches remain effective under changing climatic and socio-economic conditions.

Conclusion

Landscape resource conservation provides a powerful framework to address the intertwined challenges of land degradation, climate vulnerability, and rural poverty. The Bundelkhand region of Central India illustrates the effectiveness of integrated, science-based, and community-led strategies in restoring degraded ecosystems and improving rural livelihoods. The Bundelkhand model recognizes the interconnected nature of land, water, vegetation, and livelihoods. By aligning conservation actions with local biophysical conditions and combining traditional knowledge with modern engineering, the initiative not only optimized ecological benefits but also rebuilt community trust. Hydrological monitoring and data-led planning further

ensured interventions were targeted for maximum impact. This success offers valuable lessons for replication, especially in the 26 million hectares of fallow uplands across states like Madhya Pradesh, Uttar Pradesh, Odisha, Jharkhand, and Chhattisgarh. These regions, marked by rural distress and ecological degradation, are well-suited for landscape-based conservation.

Scaling up this model aligns with India's commitments to the SDGs, particularly those related to hunger, clean water, climate action, and terrestrial ecosystems. To mainstream such approaches, policy integration, community engagement, technical training, and investment are essential. This also helps in advancing national goals on climate adaptation, land degradation neutrality, water security, and rural prosperity. A coordinated and scientifically grounded policy framework is essential to unlock the full potential of India's drylands. Programs like MGNREGS and PMKSY can be vehicles for implementation. The Bundelkhand experience underscores that landscape restoration is both an ecological necessity and a pathway to resilient, self-reliant rural development.

Key Takeaways for Policymakers

- Integrated landscape restoration in Bundelkhand significantly improved water availability, land productivity, and rural livelihoods.
- Effective cross-sectoral coordination and convergence of government schemes, coupled with the integration of scientific tools, data, and diagnostics into planning and execution, proved crucial to success, ensuring efficient resource utilization and achieving impact at scale.
- Evidence-based interventions such as watershed management and community mobilization offer a replicable model for other drought-prone, degraded regions.
- Policy support should focus on institutionalizing collaboration and scaling up proven strategies for ecosystem restoration and climate resilience.

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About

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a pioneering non-profit organization focused on scientific research for development, committed to transforming dryland farming and agri-food systems. Working with global partners, ICRISAT develops innovative solutions to address hunger, poverty, and environmental degradation, benefiting 2.1 billion people across the drylands of Asia, Africa, and beyond.

ICRISAT was established under a Memorandum of Agreement between the Government of India and CGIAR, dated 28 March 1972. In accordance with the Headquarters Agreement, the Government of India has extended the status of a specified "International Organization" to ICRISAT under section 3 of the United Nations (Privileges and Immunities) Act, 1947 of the Republic of India through Extraordinary Gazette Notification No. UI/222(66)/71, dated 28 October 1972, issued by the Ministry of External Affairs, Government of India.



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