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Original Article

To study The Multidisciplinary Geography of Climate-Smart Villages in Rural India @2047

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Abstract

The vision of Viksit Bharat @2047 aims to achieve a developed, sustainable, and resilient nation. However, a significant portion of India's population—nearly 65%—still lives in rural areas, where agriculture-based livelihoods are increasingly vulnerable to climate change. This study explores the Climate-Smart Village (CSV) approach as an effective strategy for rural transformation by combining climate adaptation, mitigation, and productivity improvement within a single framework. Using insights from recent policy developments, such as the CSIR SMART Village Mission initiated in December 2025, along with field-based evidence from the Indo-Gangetic Plains and emerging state- level strategies in Telangana, the paper highlights the potential of CSV models as scalable and adaptable solutions aligned with national development priorities. The findings suggest that CSV initiatives contribute to higher agricultural productivity, increased farmer incomes, and reduced exposure to climate-related risks. In addition, these interventions support gender empowerment by strengthening knowledge systems and enhancing local capacities. Despite these positive outcomes, several challenges remain, including unequal access to resources, limited inclusion of smallholder farmers in carbon market mechanisms, and insufficient integration of indigenous knowledge with modern technological solutions. To address these issues, the paper proposes a five-pillar framework for implementing CSVs: Climate-Resilient Agriculture, Water-Food-Energy Integration, Digital and Artificial Intelligence Applications, Institutional Strengthening with Gender Inclusion, and Bioeconomy with Carbon Equity. The study concludes by recommending policy measures to expand and adapt the CSV approach across India's diverse agro-ecological regions, contributing to the long- term vision of national development by 2047.

Keywords: *Climate-Smart Villages, Viksit Bharat 2047, rural resilience, climate adaptation, gender empowerment, bioeconomy, carbon equity, sustainable agriculture*

Introduction

When Prime Minister Narendra Modi introduced the vision of *Viksit Bharat @2047*, which aspires to transform India into a developed nation by the centenary of its independence, the narrative has often emphasized urban growth—highlighting smart cities, advanced transport systems, innovation hubs, and financial centers. However, such an urban-focused perspective can overlook a crucial demographic fact: a majority of India's population still resides in rural areas, with a large share of the workforce depending on agriculture for their livelihood. This contrast reflects a deeper structural imbalance in the Indian economy. While agriculture contributes a relatively modest share to the national income, it continues to support a significant portion of the population. This imbalance leads to challenges such as low productivity, disguised unemployment, and heightened exposure to environmental risks.

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The situation is further intensified by climate change, which has introduced irregular rainfall patterns, rising temperatures, declining groundwater levels, and more frequent extreme weather events, making conventional farming practices increasingly uncertain and less viable. According to projections by the Intergovernmental Panel on Climate Change, crop yields— particularly for key staples like wheat and rice—could decline significantly in the coming decades if adaptive strategies are not effectively implemented. These concerns highlight the urgency of adopting sustainable and climate-resilient agricultural approaches. In this context, the Climate-Smart Village (CSV) approach presents a promising strategy for rural transformation. Emerging from the broader concept of Climate-Smart Agriculture promoted by organizations such as the Food and Agriculture Organization and the CGIAR Research Program on Climate Change, Agriculture and Food Security, the CSV model applies these principles at the village level. It emphasizes a holistic system in which farming practices, resource management, energy use, and local institutions are aligned to address climate challenges. Rather than focusing solely on infrastructure, a Climate-Smart Village represents an integrated framework aimed at achieving three key objectives simultaneously: enhancing agricultural productivity and farmer incomes, strengthening resilience to climate variability, and reducing environmental impact through mitigation of greenhouse gas emissions wherever feasible.

Objective-

To examine how multidisciplinary geographical approaches can support the development of climate-smart villages for achieving sustainable and resilient rural transformation in India by 2047.

1. To examine the role of multidisciplinary geography in understanding and developing climate- smart village systems.
2. To analyze the evolving policy landscape, from initial pilot projects to large-scale mission initiatives leading up to 2047.
3. To evaluate the five-pillar framework designed for the implementation of climate-smart villages in the context of long-term national goals.
4. To assess the application of geospatial technologies, including GIS, remote sensing, and digital mapping, in the planning, execution, and monitoring of climate-smart village programs.
5. To identify key challenges and propose policy recommendations for the effective implementation of climate-smart village models across different regions of India

The Multidisciplinary Geography of Climate-Smart Villages

The CSV approach is inherently geographic and multidisciplinary. It requires integration of:

1. **Physical Geography:** Focuses on analyzing soil characteristics, watershed dynamics, local climatic variations, and ecological regions to design interventions suited to specific environmental conditions.
2. **Human Geography:** Examines patterns of settlement, land ownership structures, migration trends, and social hierarchies to promote fair and inclusive distribution of benefits.
3. **Agricultural Science:** Emphasizes the development of climate-resilient crop varieties, improved soil management techniques, and efficient irrigation practices to enhance productivity.
4. **Energy Systems Engineering:** Involves the adoption of renewable energy technologies to support activities such as irrigation, storage, and agro-processing.

5. Digital Technologies: Utilizes tools like artificial intelligence, the Internet of Things (IoT), remote sensing, and mobile applications to enable precision farming and informed decision-making.

6. Institutional Economics: Addresses the creation of effective governance structures, financial systems, and market connections that facilitate farmer participation and equitable returns.

7. Gender Studies: Highlights the need to consider the distinct challenges and contributions of women in agriculture, ensuring inclusive development and capacity building.

This study integrates these diverse disciplinary perspectives to propose a holistic framework for implementing Climate-Smart Villages, aiming to support sustainable and resilient rural development in India by 2047.

Policy Landscape: From Pilots to Mission Mode

A Memorandum of Understanding (MoU) was established with Bal Raksha Bharat, New Delhi, which has been entrusted with implementation responsibilities to ensure effective execution at the grassroots level. The Rajasthan government has extended institutional support to facilitate the initiative. The program also encouraged direct engagement between local communities and scientific experts, reflecting strong participation from villagers—an essential element for ensuring long-term sustainability and success. Dr. Kishor S. Kulkarni, serving as Principal Scientist at CSIR-CBRI, Roorkee, has been designated as the Nodal Coordinator for the CSIR SMART Village

Mission. This initiative highlights CSIR's dedication to promoting rural development through scientific innovation, with a focus on utilizing indigenous technologies to build resilient, self-sufficient, and sustainable village systems across the country.At the state level, Telangana has introduced a forward-looking development strategy under its "Rising by 2047" vision. This framework aims to transform agriculture into a climate-resilient and technology-driven sector. The plan envisions a modern agricultural system supported by detailed land mapping, efficient water resource management, and improved market linkages to enhance farmers' income and sustainability

Policy Landscape: From Pilots to Mission Mode		
a) The CSIR SMART Village Mission: A Flagship Initiative	**Housing and Infrastructure**	• Adoption of cool roofing solutions to lower indoor heat and improve thermal comfort. • Development of affordable housing using locally available and sustainable materials. • Construction of rural roads using techniques designed to withstand climate-related stresses
	Renewable Energy and Water Management:	• Use of solar-supported heat pump technologies for energy-efficient applications. • Treatment systems for wastewater and fecal sludge to ensure sanitation and environmental safety. • Technologies designed to provide clean and safe drinking water. • Tools and methods for assessing and monitoring groundwater resource
	Agriculture and Allied Sectors:	1• Cultivation of aromatic and medicinal plants to enhance farm income through high-value produce. • Promotion of beekeeping to improve crop pollination while generating supplementary earnings. • Value addition in millet production to increase market potential and profitability. • Use of advanced farm equipment to support precision-based agricultural practices.
	Waste Management:	• Management of solid waste through innovative approaches, including the use of granite waste for making paving materials. • Promotion of environmentally friendly, biodegradable products to reduce pollution. • Adoption of biogas and composting techniques for effective organic waste utilization.
	Digital and AI-Enabled Systems:	•.Smart energy management •.Wildlife conflict mitigation •.Health monitoring •Milk quality analysis

b)Telangana's "Rising by 2047": Climate-Smart Agriculture Blueprint	**Soil Health Infrastructure:**	• Deployment of mobile soil testing systems capable of processing millions of samples each season. • Provision of geo-referenced soil health cards offering crop-specific recommendations. • Capacity-building initiatives that train women's groups and field personnel as local soil health facilitators. • Development of integrated soil intelligence platforms that combine soil data with crop and climate information for better decision-making
	Water Management	•.IoT-based micro-irrigation covering 39.5 lakh acres •.Smart irrigation dashboard for predictive water management •.Target to increase farm power availability from 3.5 kW/ha to 9 kW/ha through renewable-powered systems
	Natural Farming:	•.Scaling natural farming across 4,000 villages •.1,000 Telangana natural farming clusters led by kisan mitras and women green champions •.Bio-input centres and links to premium markets
	Research and Innovation	•Enhancing the capacity and role of agricultural universities in research and innovation. •Transforming PJTSAU's Ag-Hub into a comprehensive AgTech research and certification center. •Establishing integrated systems for testing and certifying agri-drones, IoT-based devices, and AI-driven tools. •Creating a dedicated funding mechanism to support agricultural technology research. •Setting up a specialized center for research on nano-based agricultural inputs. •Developing an agriculture bioinformatics network that integrates genomic, soil, and climate data for advanced analysis.
	Value Addition and Market Linkages:	• Expanding oil palm cultivation significantly to strengthen production capacity. • Increasing overall oilseed output to meet growing demand. • Development of large-scale horticulture clusters to boost productivity and market access. • Promotion of vegetable cultivation zones around urban areas to ensure steady supply. • Establishment of specialized commodity clusters to enhance agricultural value chain6.Dedicated rice export wing with AI, IoT, and blockchain integration

	Sericulture Expansion:	• Achieving national prominence in silk production by the year 2047. • Expanding the area under mulberry cultivation to significantly increase raw material availability. • Substantially enhancing the production of raw mulberry silk to meet future demand. • Accelerating growth in tasar silk output through focused development initiatives.
c)The BioE3 Mission: Bioeconomy for Rural Transformation		• The BioE3 (Bioeconomy for Environment, Employment, and Energy) mission serves as an important policy component supporting the implementation of Climate-Smart Villages. • Introduced under India's broader bioeconomy strategy, the initiative focuses on expanding the bio-based economy by promoting environmentally sustainable practices, generating employment opportunities, and strengthening clean energy systems, while encouraging rural participation in this transition. •By promoting the cultivation of feedstocks such as dent corn, Napier grass, bamboo, agricultural residues, and algae, farmers can contribute to the production of biofuels and bio-based products, including bioethanol, sustainable aviation fuel, bioplastics, bio-chemicals, and bio-CNG. These outputs support decarbonization across industries such as energy, aviation, and consumer goods, while also creating additional income opportunities for rural communities.

A Five-Pillar Framework for Climate-Smart Villages @2047

Pillar NO	NAME OF Pillar	Objective	Key Interventions	Targets for 2047
Pillar-I	Climate-Resilient Agriculture	**Objective**- Transform agricultural systems to be productive, adaptive, and low-emission	11.Cropdiversification Climate 2.Climate-resilie varieties 3.Soil health 4.management Integrated pest management 5.Agroforestry	150% of gross cropped area under climate-resilient practices 2.25% reduction in chemical fertilizer use through precision and organic alternatives 3.30% increase in soil organic carbon across agricultural lands 4.10 million hectares under agroforestry
Pillar-II	Water-Food-Energy Nexus	**Objective-**Achieve integrated management of water, food, and energy systems at village scale	1.Micro-irrigation 2.Solar-powered irrigation 3.Watershed development 4.Wastewater treatment and reuse 5.Rainwater harvesting 6.Floating solar	1.100% of suitable area under micro-irrigation 2.50% reduction in groundwater depletion in over-exploited blocks 3.50% of agricultural energy from renewable sources 4.50% of rural wastewater treated and reused
Pillar-III	Digital and AI Integration	**Objective-** Leverage digital technologies for climate information, decision support, and market access	1.Village-level weather stations 2.Soil moisture sensors and IoT platforms 3.AI-powered crop advisory 4.Digital market platforms 5.Blockchain for traceability Farmer-centric digital identity	1.100% of villages covered by hyperlocal weather and agro-advisory services 2.50% of farmers using digital platforms for market access 3.25% increase in farmer income through reduced transaction costs and better price realization
Pillar-IV	Institutional and Gender Empowerment	**Objective-**: Build inclusive institutions that enable equitable participation and benefit sharing	1.Women's self-help groups (SHGs) 2.Farmer producer organizations (FPOs) Community-based 3.monitoring Capacity building 4.Land rights regularization 5.Youth engagement	1.50% of CSV leadership positions held by women and marginalized community members 2.100% of villages covered by functional FPOs or SHG networks 3.25% increase in women's agricultural income 4.50% reduction in gender gap in access to extension services and credit
Pillar-V	Bioeconomy and Carbon Equity	**Objective:** Enable farmers to benefit from emerging carbon markets and bioeconomy opportunities	1.Carbon credit aggregation 2.Direct benefit transfer 3.Sustainable feedstock (cultivation) 4.Decentralized bioenergy 5.Value addition 6.Carbon-smart village certification enabling premium pricing for low-carbon products	1.10 million farmers participating in carbon credit markets 2.US$10 billion annual carbon credit revenue to farming households 3.50% reduction in crop residue burning through bioeconomy valorization 4.25% of rural energy from decentralized bioenergy

Benefits of Geospatial Tools in Climate-Smart Village

The use of geospatial technologies—such as GIS, remote sensing, and digital mapping—plays a crucial role in strengthening climate-smart village initiatives. These tools enhance planning efficiency, support informed decision-making, and contribute to sustainable rural development.

1. **Informed Decision-Making**

Geospatial systems generate precise, location-based information on soil conditions, water availability, climate patterns, and land use. This enables farmers and policymakers to make well-informed choices regarding crop planning, irrigation strategies, and resource allocation.

2. **Optimized Resource Utilization**

GIS and remote sensing techniques assist in mapping and assessing natural resources, including water bodies, forests, and agricultural land. This promotes efficient utilization and minimizes unnecessary depletion.

3. **Climate Risk Assessment and Preparedness**
Satellite-based observations help detect environmental risks such as drought, flooding, and land degradation at an early stage. This supports timely responses and strengthens disaster preparedness in rural areas.
4. **Increased Agricultural Productivity**
Digital mapping tools contribute to precision agriculture by guiding farmers on suitable crop varieties, planting schedules, and soil management practices, ultimately improving yields and food security.
5. **Continuous Monitoring and Evaluation**
Geospatial data enables regular tracking of environmental changes, including vegetation cover, soil moisture, and land-use patterns. This helps assess the effectiveness and progress of implemented interventions.
6. **Time and Cost Efficiency**
By reducing dependence on extensive field surveys, geospatial technologies save both time and financial resources. Large geographic areas can be analyzed efficiently through satellite imagery.
7. **Improved Infrastructure Planning**
Digital mapping supports the strategic placement of infrastructure such as irrigation systems, water conservation structures, and renewable energy facilities, ensuring maximum effectiveness.
8. **Greater Transparency and Accountability**
GIS-based visualization tools, including maps and dashboards, provide clear and verifiable records of project activities, enhancing transparency and governance.
9. **Promotion of Sustainable Development**
These technologies support environmentally responsible practices by aiding in biodiversity conservation, maintaining ecological balance, and reducing climate-related impacts.
10. Strengthening Community Participation
When integrated with mobile-based applications, geospatial tools enable local communities to actively engage in data collection and decision-making, fostering awareness and ownership of development initiatives.

Policy Recommendations

Formulate a dedicated national mission for Climate-Smart Villages under the Ministry of Rural Development, ensuring coordination among key sectors such as agriculture, environment, energy, and local governance.

1. **Incorporate the climate**-smart village framework into existing government schemes like MGNREGA for natural resource management, PM-KISAN for supporting sustainable farm inputs, and DAY-NRLM for strengthening women's self-help groups.
2. Ensure that all interventions follow principles of gender equality and social inclusion, supported by community-led monitoring systems to avoid unequal distribution of benefits.
3. Enhance the capacity of Panchayati Raj Institutions to effectively plan, execute, and supervise climate-smart village initiatives by providing adequate funding and training.
4. Develop specialized knowledge and resource centers at agricultural universities and Krishi Vigyan Kendras to promote research, capacity building, and extension services related to climate-smart practices.
5. Establish a blended financing mechanism that combines public funding, international climate finance, and private sector investments to support climate-smart village initiatives.
6. Design simplified carbon credit systems tailored to small-scale farmers, ensuring easy verification processes and fair distribution of benefits directly to rural communities.
7. Introduce certification systems for climate-smart villages to enable better market access and premium pricing for sustainably produced goods.
8. Strengthen agricultural insurance schemes by extending coverage to climate-resilient practices and offering subsidized premiums for farmers adopting such approaches.
9. Promote innovation in agricultural technologies through dedicated funding, with a focus on solutions that are accessible and affordable for small and marginal farmers, including women.
10. Develop a comprehensive monitoring and evaluation system to track progress in areas such as productivity, income, climate resilience, social inclusion, and environmental impact.
11. Encourage participatory research models where farmers actively contribute to knowledge creation and innovation processes.
12. Integrate climate-smart village concepts into agricultural education and training programs to build long-term capacity among future practitioners.
13. Recognize and incorporate traditional and indigenous knowledge systems that contribute to climate resilience into modern planning frameworks.

Conclusion

Achieving the vision of Viksit Bharat @2047 depends significantly on the transformation of rural India into a resilient, productive, and inclusive space. If rural regions continue to face vulnerability

and limited access to development opportunities, national progress will remain incomplete. In this context, the Climate-Smart Village (CSV) approach emerges as a comprehensive strategy that simultaneously addresses food security, climate adaptation, and mitigation through a community-focused and integrated framework.

Recent policy initiatives indicate a growing commitment toward this transformation. Programs such as the CSIR-led SMART Village Mission and long-term state-level development plans demonstrate how scientific knowledge and strategic planning can be combined to promote sustainable rural development. Additionally, emerging bioeconomy initiatives are opening new avenues for farmers to diversify income sources and participate in environmentally sustainable economic activities.

Field-based studies, particularly from agriculturally important regions like the Indo-Gangetic Plains, reveal that climate-smart practices can enhance agricultural productivity, increase farmer incomes, and reduce climate-related risks. These approaches have also shown potential in promoting social inclusion, especially by supporting the participation and empowerment of women. However, it is important to recognize that unequal social structures and power dynamics within rural communities may influence how benefits are distributed, requiring careful and inclusive implementation strategies. The framework discussed in this study—covering climate-resilient agriculture, integrated resource management, digital and technological innovation, institutional support with gender inclusion, and bioeconomic opportunities—provides a holistic pathway for implementing climate-smart villages. This approach ensures that both environmental sustainability and social equity are addressed together. Importantly, the concept of climate-smart villages acknowledges India's diverse geographical and socio-cultural conditions. Rather than applying a uniform model, it emphasizes context-specific solutions tailored to local needs, resources, and capacities. This flexibility is essential for ensuring long-term success across different regions of the country. As India moves toward its 100th year of independence, the expansion of climate-smart villages can play a crucial role in building a sustainable and equitable rural future. Strengthening rural livelihoods, restoring ecological balance, and enhancing community resilience are not only developmental priorities but also essential steps toward achieving a more inclusive and sustainable nation

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