

CLIMATE VULNERABILITY REDUCTION FOR SMALL AND MARGINAL FARMERS IN UTTARAKHAND, INDIA

KYAWT YIN MIN THEIN



**CENTER FOR RURAL DEVELOPMENT AND TECHNOLOGY
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by

KYAWT YIN MIN THEIN

CENTER FOR RURAL DEVELOPMENT AND TECHNOLOGY

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CERTIFICATE

This is to certify that the thesis entitled “**CLIMATE VULNERABILITY REDUCTION FOR SMALL AND MARGINAL FARMERS IN UTTARAKHAND, INDIA**”, is being submitted by **Ms. Kyawt Yin Min Thein** to the Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy, is a record of bona fide research work carried out by her. **Ms. Kyawt Yin Min Thein** has worked under our guidance and supervision and has fulfilled the requirements for submitting this thesis, which, to our knowledge, has reached the requisite standard.

The results contained in this thesis are original. They have not been submitted, in part or whole, to any other University or Institute for the award of any other degree or diploma.

Dr. Vivek Kumar

Professor & Head

Center for Rural Development & Technology
Indian Institute of Technology Delhi
Hauz Khas, New Delhi- 110016
India

Dr. Vijayaraghavan M Chariar

Professor

Center for Rural Development &
Technology
Indian Institute of Technology Delhi
Hauz Khas, New Delhi- 110016
India

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ABSTRACT

Climate change poses serious threats to rural livelihoods, particularly for small and marginal farmers living in fragile ecosystems such as the hilly regions of Uttarakhand, India. These communities face multiple stressors, including erratic rainfall, frequent landslides, flooding, and soil erosion, all of which exacerbate livelihood insecurity. Recognizing this, the present study investigates how farm households perceive and respond to climate-related risks, and how their adaptive capacity can be strengthened through sustainable agricultural practices.

The study applies a mixed-methods approach that combines quantitative and qualitative research. Household survey data were collected from 367 households in Bageshwar district, Uttarakhand, covering socio-demographic profiles, livelihood strategies, health, food security, water resources, exposure to natural hazards, and adaptation barriers. Two established frameworks were employed to assess climate vulnerability: the Livelihood Vulnerability Index (LVI) and the Climate Vulnerability Index (CVI), both adapted to local conditions using 42 context-specific indicators. Additionally, the Garrett Ranking Technique (GRT) was used to rank key problems and barriers faced by farmers in implementing adaptation strategies. Focus group discussions, key informant interviews, and stakeholder consultations further enriched the analysis with qualitative insights.

The findings demonstrate variations in vulnerability across villages. According to the LVI, Wali village (0.093) is the most vulnerable, followed by Pali (0.073), while Ason (-0.01) is the least vulnerable. The CVI results, however, show relatively similar values, with Ason village (1.056) being the most vulnerable, followed by Pali (1.014) and Wali (1.007), the least vulnerable. These differences highlight the importance of using multiple indices for assessing vulnerability, as each captures distinct dimensions of household exposure, sensitivity, and adaptive capacity.

Determinants of adaptation were further examined using logistic regression analysis, revealing that education significantly influences the adoption of improved crop varieties, farm experience enhances adaptation, migration patterns shape diversification choices, and market distance negatively affects the uptake of sustainable practices. Land constraints emerged as a major barrier to crop rotation and diversification. Collectively, these results

underscore the central role of socio-economic characteristics, institutional access, and infrastructural limitations in shaping climate resilience.

Building on these insights, the study proposes a framework for sustainable agricultural practices tailored to the hilly regions of Uttarakhand. The framework integrates crop diversification, organic farming, agroforestry, permaculture, integrated pest management, and conservation tillage. It also emphasizes institutional support, market access, low-cost technologies, and gender-sensitive interventions. By linking farmer-driven practices with enabling policies, the design provides a roadmap for strengthening resilience while addressing both ecological sustainability and livelihood security.

The research also identifies key challenges and limitations. Limited geographical coverage restricts the generalizability of results, and cross-sectional data may not fully capture seasonal or long-term adaptation dynamics. Structural factors such as government subsidies, national climate policies, and global market fluctuations were not directly modeled, though they are influential. Despite these limitations, the study provides a robust empirical foundation for understanding vulnerability and adaptation in mountain agriculture.

In terms of policy implications, the study highlights the need for capacity-building programs, targeted subsidies, improved rural infrastructure, and accessible extension services. Investments in climate-resilient seeds, insurance schemes, and community-based adaptation initiatives are essential. Furthermore, migration-sensitive policies should enable remittance investment in farming, while gender-responsive approaches are needed to ensure equitable access to resources and decision-making.

In conclusion, this dissertation contributes to both academic and policy discussions on climate change and rural livelihoods. By applying and comparing the LVI and CVI frameworks, it advances methodological approaches to vulnerability assessment. By analyzing determinants of adaptation, it deepens understanding of the socio-economic and institutional drivers of resilience. Finally, by proposing a sustainable agricultural framework, it offers practical pathways for empowering small and marginal farmers to cope with climate risks in Uttarakhand and similar hilly regions.

सार

जलवायु परिवर्तन ग्रामीण आजीविका के लिए गंभीर खतरा पैदा करता है, खासकर भारत के उत्तराखंड के पहाड़ी क्षेत्रों जैसे नाजुक पारिस्थितिक माहौल में रहने वाले छोटे और सीमांत किसानों के लिए। ये समुदाय कई तरह के तनावों का सामना करते हैं, जिनमें अनियमित वर्षा, बार-बार होने वाले भूस्खलन, बाढ़ और मृदा अपरदन शामिल हैं, जो आजीविका की असुरक्षा को और बढ़ाते हैं। इसे ध्यान में रखते हुए, यह अध्ययन इस बात की पड़ताल करता है कि किसान परिवार जलवायु संबंधी जोखिमों को कैसे समझते हैं और उनका कैसे सामना करते हैं, और टिकाऊ कृषि पद्धतियों के माध्यम से उनकी अनुकूलन क्षमता को कैसे मजबूत किया जा सकता है।

अध्ययन में मिश्रित-पद्धति दृष्टिकोण का प्रयोग किया गया है जो मात्रात्मक और गुणात्मक अनुसंधान को सम्मिलित किया गया है। उत्तराखंड के बागेश्वर जिले के 367 समूह से घरेलू सर्वेक्षण आँकड़े एकत्रित किये, जिनमें सामाजिक-जनसांख्यिकीय समस्याएँ, खाद्य रणनीतियाँ, स्वास्थ्य, खाद्य सुरक्षा, जल संसाधन, प्राकृतिक आपदाओं के प्रति जोखिम और अनुकूलन बाधाएँ शामिल थीं। जलवायु भेद्यता का आकलन करने के लिए दो स्थापित ढाँचों का उपयोग किया गया: विशिष्टता भेद्यता शोधकर्ता (एलवीआई) और जलवायु वैज्ञानिकता शोधकर्ता (सीवीआई), दोनों ने 42 संदर्भ-विशिष्ट संकेतकों का उपयोग करके स्थानीय परिस्थितियों के अनुकूल खुद को उपयुक्त बनाया। इसके अतिरिक्त, अनुकूलन रणनीतियों को लागू करने में किसानों के सामने आने वाली प्रमुख समस्याओं और बाधाओं को रैंक करने के लिए गैरेट रैंकिंग तकनीक (जीआरटी) का उपयोग किया गया। समूह फोकस चर्चाओं, प्रमुख सूचना प्रदाताओं के साक्षात्कार और हितधारक परामर्शदाताओं ने गुणात्मक सिद्धांतों के साथ विश्लेषण को और समृद्ध किया।

निष्कर्ष विभिन्न गांवों में संवेदनशीलता में भिन्नता दर्शाते हैं। एलवीआई के अनुसार, वाली गांव (0.093) सबसे अधिक असुरक्षित है, उसके बाद पाली (0.073) है, जबकि असोन (-0.01) सबसे कम

असुरक्षित है। हालांकि, सी.वी.आई. के परिणाम अपेक्षाकृत समान मान दर्शाते हैं, जिसमें असोन गांव (1.056) सबसे अधिक असुरक्षित है, उसके बाद पाली (1.014) और वली (1.007) सबसे कम असुरक्षित हैं। ये अंतर भेद्यता का आकलन करने के लिए कई सूचकांकों के उपयोग के महत्व को उजागर करते हैं, क्योंकि प्रत्येक सूचकांक घरेलू जोखिम, संवेदनशीलता और अनुकूलन क्षमता के अलग-अलग आयामों को दर्शाता है।

लॉजिस्टिक रीग्रेशन विश्लेषण का उपयोग करके अनुकूलन के निर्धारकों की और जाँच की गई, जिससे पता चला कि शिक्षा उन्नत फसल किस्मों को अपनाने में महत्वपूर्ण भूमिका निभाती है, कृषि अनुभव अनुकूलन को बढ़ाता है, प्रवासन पैटर्न विविधीकरण विकल्पों को आकार देते हैं, और बाज़ार की दूरी स्थायी प्रथाओं को अपनाने पर नकारात्मक प्रभाव डालती है। भूमि की सीमाएँ फसल चक्रण और विविधीकरण में एक प्रमुख बाधा के रूप में उभरीं। सामूहिक रूप से, ये परिणाम जलवायु लचीलेपन को आकार देने में सामाजिक-आर्थिक विशेषताओं, संस्थागत पहुंच और अवसंरचनात्मक सीमाओं की केंद्रीय भूमिका को रेखांकित करते हैं।

इन अंतर्दृष्टियों के आधार पर, यह अध्ययन उत्तराखंड के पहाड़ी क्षेत्रों के लिए अनुकूलित स्थायी कृषि पद्धतियों के लिए एक रूपरेखा प्रस्तावित करता है। यह रूपरेखा फसल विविधीकरण, जैविक खेती, कृषि वानिकी, पर्माकल्चर, एकीकृत कीट प्रबंधन और संरक्षित जुताई को एकीकृत करती है। यह अध्ययन संस्थागत समर्थन, बाज़ार पहुंच, कम लागत वाली तकनीकों और लैंगिक-संवेदनशील हस्तक्षेपों पर भी ज़ोर देता है। किसान-संचालित पद्धतियों को सक्षम नीतियों से जोड़कर, यह डिज़ाइन पारिस्थितिक स्थिरता और आजीविका सुरक्षा दोनों को संबोधित करते हुए लचीलेपन को मज़बूत करने का एक रोडमैप प्रदान करता है।

शोध प्रमुख चुनौतियों और सीमाओं की भी पहचान करता है। सीमित भौगोलिक कवरेज परिणामों की सामान्यीकरण क्षमता को सीमित करता है, और क्रॉस-सेक्शनल डेटा मौसमी या दीर्घकालिक

अनुकूलन गतिशीलता को पूरी तरह से नहीं पकड़ पाता है। सरकारी सब्सिडी, राष्ट्रीय जलवायु नीतियों और वैश्विक बाजार में उतार-चढ़ाव जैसे संरचनात्मक कारकों को सीधे तौर पर मॉडल नहीं किया गया, हालाँकि वे प्रभावशाली हैं। इन सीमाओं के बावजूद, यह अध्ययन पर्वतीय कृषि में भेद्यता और अनुकूलन को समझने के लिए एक मजबूत अनुभवजन्य आधार प्रदान करता है।

नीतिगत निहितार्थों के संदर्भ में, अध्ययन क्षमता निर्माण कार्यक्रमों, लक्षित सब्सिडी, बेहतर ग्रामीण बुनियादी ढाँचे और सुलभ विस्तार सेवाओं की आवश्यकता पर प्रकाश डालता है। जलवायु-अनुकूल बीजों, बीमा योजनाओं और समुदाय-आधारित अनुकूलन पहलों में निवेश आवश्यक है। इसके अलावा, प्रवासन-संवेदनशील नीतियों को कृषि में धन प्रेषण निवेश को सक्षम बनाना चाहिए, जबकि संसाधनों और निर्णय लेने की प्रक्रिया तक समान पहुँच सुनिश्चित करने के लिए लिंग-संवेदनशील दृष्टिकोणों की आवश्यकता है।

निष्कर्षतः, यह शोध प्रबंध जलवायु परिवर्तन और ग्रामीण आजीविका पर अकादमिक और नीतिगत चर्चाओं में योगदान देता है। एलवीआई और सीवीआई ढाँचे को लागू करने और उनकी तुलना करने से, यह भेद्यता मूल्यांकन के लिए पद्धतिगत दृष्टिकोण को आगे बढ़ाता है। अनुकूलन के निर्धारकों का विश्लेषण करके, यह लचीलेपन के सामाजिक-आर्थिक और संस्थागत चालकों की समझ को गहरा करता है। अंत में, एक स्थायी कृषि ढाँचे का प्रस्ताव करके, यह उत्तराखंड और इसी तरह के पहाड़ी क्षेत्रों में जलवायु जोखिमों से निपटने के लिए छोटे और सीमांत किसानों को सशक्त बनाने के लिए व्यावहारिक रास्ते प्रदान करता है।

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LIST OF ABBREVIATIONS AND NOTATIONS

ACI	Adaptation Capability Index
ARDL	Autoregressive Distributed Lag Model
Adp	Adaptive Capacity
CSA	Climate-Smart Agriculture
COP	Conference Of Parties
CI	Composite Index
CV	Climate Variability
CVI	Climate Change Vulnerability Index
CLVI	Climate Livelihood Vulnerability Index
EWS	Early Warning Systems
Exp	Exposure
FEWS	Famine Early Warning System
FPOs	Farmer Producer Organizations
GRT	Garett Ranking Technique
GoI	Government of India
HDI	Human Development Index
HHs	House Holds
HYV	High-Yielding Varieties
IHR	Indian Himalayan Region
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
LPG	Liquefied Petroleum Gas
LVI	Livelihood Vulnerability Index
MLR	Multinomial Logistic Regression

NDIM	New Delhi Institute of Management
NGOs	Non-Governmental Organizations
OECD	Organization for Economic Co-operation and Development
PSI	People's Science Institute
Sen	Sensitivity Index
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change.
UP	Uttar Pradesh
UN-IPCC	United Nations- Intergovernmental Panel on Climate Change
VTs	Village Tracts
WFP	World Food Programme