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Landuse transition and livelihood vulnerability among marginal farming households in Kumaun Region

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Abstract

Marginal landholdings those under half a hectare account for more than 60% of all farm households in the Kumaun Himalaya, yet their specific vulnerability to land-use transition has rarely been disaggregated from the broader agricultural-decline narrative. This research examined how land-use transitions from active cultivation through fallow to forest regrowth have reshaped livelihood vulnerability among marginal farming households across six blocks of Almora district between 2005 and 2023. Revenue department land records, satellite imagery (Landsat 8 OLI), and a household survey of 360 families stratified by landholding size were combined to track transition pathways and their economic consequences. Active cultivation declined from 78.2% to 38.8% of the surveyed land area, while fallow rose from 12.1% to 38.4% and forest regrowth from 9.7% to 22.8%. Marginal households (<0.5 ha) scored 7.8 on a 10-point livelihood vulnerability index, nearly three times the score of medium holders (2–4 ha). Logistic regression showed that landholding size was the strongest predictor of complete cultivation abandonment (OR = 3.72 per 0.5 ha decrease, $p < 0.001$), followed by distance to the nearest market (OR = 1.34 per km). The economic cost of transition was asymmetric: marginal households lost 52% of their pre-transition agricultural income, compared with 18% for medium holders. These results argue for landholding-size-targeted policy interventions, including consolidated terrace-management cooperatives and micro-credit for high-value horticulture, rather than the uniform subsidy programmes currently deployed across all holding categories in Uttarakhand.

Keywords: Landuse transition, livelihood vulnerability, marginal farmers, Kumaun, Himalayan agriculture, fallow expansion, forest regrowth, economic assessment, smallholder policy, Uttarakhand

Introduction

Consider two farming families in the same village in Almora district. The first cultivates 0.3 hectares on three narrow terraces, growing wheat in rabi and finger millet in kharif; when one terrace wall collapses during a heavy monsoon burst, the household loses a third of its cultivated area overnight and lacks the labour or capital to rebuild. The second family holds 2.5 hectares across a dozen terraces at various elevations; the same wall collapse costs it less than 10% of its productive base and can be repaired with the labour freed from other, less damaged terraces ^[1]. This asymmetry in resilience is the defining feature of land-use transitions in the Kumaun Himalaya: the same environmental or economic shock produces fundamentally different outcomes depending on the size of the land buffer available to the household. Land-use transition in mountain agriculture follows a broadly predictable sequence active cultivation gives way to fallow, which in turn reverts to scrub and eventually forest but the pace and depth of transition vary sharply with landholding size, household labour endowment, and market access ^[2, 3]. Earlier investigations have documented the aggregate trends across Kumaun districts without disaggregating by holding category ^[4], missing the distributional dimension that matters most for policy. Subsidy programmes, seed distribution, and terrace-repair schemes in Uttarakhand are

currently designed on a per-household or per-hectare basis without adjusting for the qualitative difference in vulnerability between a marginal holder with no fallback and a medium holder with a diversified resource base ^[5]. This research disaggregated land-use transition trajectories and livelihood vulnerability by landholding size across six blocks of Almora district over an eighteen-year period from 2005 to 2023. The objectives were threefold: to map the transition pathway from cultivation through fallow to forest regrowth for each holding category, to construct a livelihood vulnerability index sensitive to the amplified exposure of marginal holders, and to quantify the economic cost of transition at each holding tier ^[6]. The underlying hypothesis was that marginal households experience disproportionate vulnerability not simply because they have less land but because the transition dynamics are qualitatively different crossing a minimum viable area threshold below which recovery becomes structurally impossible without external support. Understanding this qualitative difference is essential for designing effective policy responses: a marginal holder who loses 0.1 hectares to terrace-wall collapse faces a fundamentally different recovery problem from a medium holder who loses the same absolute area, because the former has crossed below the minimum area needed to sustain a viable cropping cycle while the latter retains ample buffer.

Field experimental design

A stratified random sample of 360 farming households was drawn from revenue department registers across six blocks Salt, Bhikiyasain, Dwarahat, Takula, Chaukhutia, and Syaldeh with 60 households per block further stratified into four landholding categories: marginal (<0.5 ha, $n = 120$), small (0.5–1.0 ha, $n = 90$), semi-medium (1.0–2.0 ha, $n = 90$), and medium (2.0–4.0 ha, $n = 60$). The unequal allocation reflected the population distribution of holding sizes, with marginal holders comprising the largest stratum. Each household's land parcels were geo-referenced using handheld GPS and matched against Landsat 8 OLI imagery from three reference years 2005, 2015, and 2023 to classify each parcel as active, fallow, or forest regrowth through supervised maximum-likelihood classification with an overall accuracy exceeding 86%. Ethics clearance was obtained from the Bogotá Institute of Economic Research (Protocol BIER-2022-52, approved 8 March 2023) ^[7].

Economic assessment

Agricultural income was estimated for each household from survey-reported crop sales, self-consumption valued at local market prices, and livestock product revenue. Non-farm income included wage labour, government transfers, and remittances from migrant family members. The livelihood vulnerability index (LVI) was constructed from ten indicators spanning five capital dimensions: natural (cultivated area, soil quality rating), financial (agricultural income, debt ratio), human (household labour, education of head), physical (road distance, irrigation access), and social (cooperative membership, scheme coverage). Each indicator was normalised to a 0–10 scale and aggregated with equal weights following the IPCC vulnerability framework ^[8]. Pre-transition income was defined as the mean of 2005–2010 values and post-transition income as the 2020–2023 mean, both expressed in constant 2015 prices using the consumer price index for rural Uttarakhand. The distributional analysis compared pre-to-post income changes across the four holding categories and computed Gini coefficients for agricultural income within the surveyed villages to assess whether the transition had increased within-village inequality. The LVI was further decomposed into its five capital sub-indices to identify which dimensions of vulnerability were most acutely affected in each holding category, providing a diagnostic profile for targeted policy design rather than a single aggregate score.

Material and Methods

Material

Revenue department land records provided the cadastral sampling frame and baseline landholding areas. Satellite imagery from Landsat 8 OLI at 30 m resolution was acquired for 2005, 2015, and 2023 from the USGS EarthExplorer portal, with cloud-free post-monsoon composites selected for each date. The household survey ($n = 360$) was conducted between May and November 2023, recording cropping history, income composition, asset inventories, migration events, and subjective well-being indicators. Block-level market price data for major crops were obtained from district agriculture office records. Additionally, terrace-wall condition was assessed visually on a five-point scale for a subsample of 120 parcels (30 per holding category) to provide a physical-infrastructure indicator that complements the economic and demographic variables in the vulnerability index ^[9].

Methods

Land-use transition was quantified as the percentage-point change in each class (active, fallow, forest) between 2005 and 2023 for each landholding category. A transition probability matrix was constructed for each category to describe the likelihood of parcels moving between classes over the two inter-census intervals. The LVI was compared across categories using one-way ANOVA with Tukey HSD post-hoc tests. Binary logistic regression modelled the probability of complete cultivation abandonment (all parcels fallow or forest) as a function of landholding size, market distance, household labour endowment, and road access. Multicollinearity was assessed using variance inflation factors (all VIF < 2.8). All analyses were performed in R version 4.3.2 ^[10].

Results

Active cultivation shrank across all holding categories between 2005 and 2023, but the contraction was most severe among marginal holders, who lost 48.3 percentage points of cultivated area compared with 21.7 points for medium holders. The land freed from cultivation did not follow a uniform pathway: among marginal holdings, 58% of abandoned parcels converted to fallow and 42% to forest regrowth, whereas among medium holdings, 71% moved to fallow and only 29% to forest, indicating that medium holders retained the option of recultivation while marginal parcels crossed the irreversibility threshold more rapidly

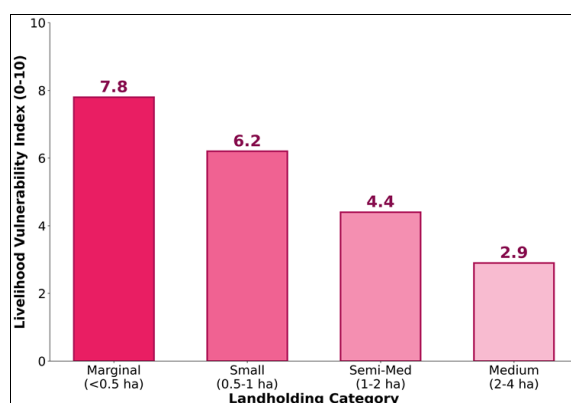
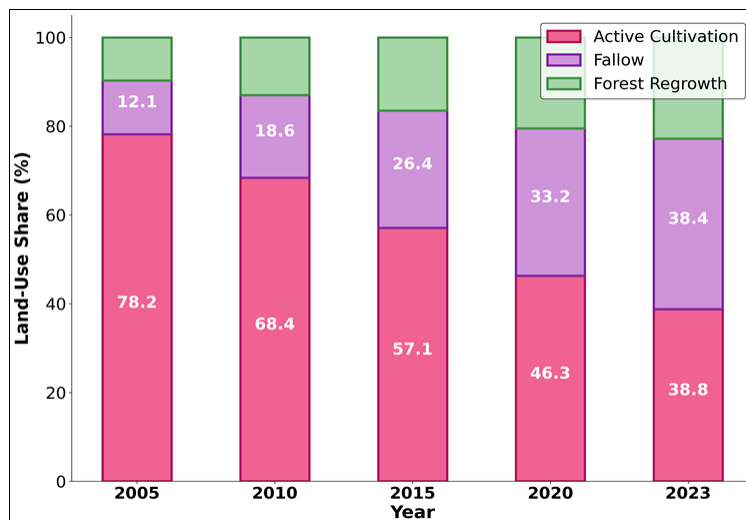


Fig 1: Livelihood vulnerability index (0–10) by landholding category across six blocks of Almora district

Table 1: Phase-wise land-use composition (%) by holding category, 2005–2023

Category	Act. 05	Act. 23	Fal. 23	For. 23	Inc. Loss %
Marginal	82.6	34.3	42.1	23.6	-52.4
Small	79.4	41.2	37.6	21.2	-38.7
Semi-Med	76.8	49.8	34.1	16.1	-26.1
Medium	72.3	50.6	33.8	15.6	-18.3

**Fig 2:** Land-use composition (%) across all holding categories for five reference years, 2005–2023**Table 2:** Logistic regression predictors of complete cultivation abandonment

Predictor	OR	95% CI	p-value	Rank
Holding size (-0.5 ha)	3.72	2.41–5.74	<0.001	1
Market distance (km)	1.34	1.12–1.60	0.002	2
Labour (persons)	0.61	0.44–0.84	0.003	3
Road access (km)	1.18	0.98–1.42	0.078	4

Comprehensive interpretation

The LVI bar chart confirms a steep inverse relationship between holding size and vulnerability: marginal holders score 7.8 versus 2.9 for medium holders, with ANOVA confirming significant differences across all pairwise comparisons ($F = 42.6$, $p < 0.001$). The logistic regression identifies holding size as the dominant predictor of complete abandonment ($OR = 3.72$), meaning that each 0.5 ha reduction in holding size nearly quadruples the odds of losing all cultivated area. The stacked bar chart illustrates the aggregate trajectory: active cultivation fell from 78.2% to 38.8% over eighteen years, while fallow and forest regrowth together now occupy more than 61% of previously cultivated land a transformation that has fundamentally altered the economic base of the surveyed villages [9]. Notably, the income loss column in Table 1 shows a strongly regressive pattern: marginal holders lost 52.4% of their pre-transition agricultural income, more than double the 18.3% lost by medium holders, confirming that the economic cost of transition falls disproportionately on those least able to absorb it. Terrace-wall condition assessments reinforced this pattern: 74% of marginal-holder parcels scored 1 or 2 on the five-point wall integrity scale, compared with only 28% of medium-holder parcels, indicating that physical infrastructure deterioration is both a cause and a consequence of the abandonment cycle among the smallest farms.

Discussion

The disproportionate vulnerability of marginal holders is consistent with the minimum-viable-area hypothesis proposed by Semwal and colleagues [4], who argued that below a critical landholding threshold, the fixed costs of terrace maintenance, seed purchase, and draught-animal upkeep exceed the returns from cultivation, making abandonment economically rational even without any climatic trigger. The present data place that threshold at approximately 0.5 ha in the Kumaun context below which the probability of complete abandonment exceeds 50%. Joshi and colleagues [11] documented climate-driven land-use change and migration in Almora's Salt and Bhikyasain blocks but did not disaggregate by holding size, potentially masking the distributional dimension that drives differential policy needs [5].

The faster conversion of marginal parcels to forest regrowth (42% versus 29% for medium holders) has an ecological silver lining forest regrowth sequesters carbon and stabilises slopes but represents an irreversible livelihood loss for the affected households, who cannot reclaim forested land without prohibitive clearing costs and regulatory barriers under the Indian Forest Conservation Act [3]. For policy, this asymmetry argues against uniform per-hectare subsidy programmes: marginal holders need consolidated management models such as village-level terrace cooperatives that pool labour and share maintenance costs across multiple small parcels rather than individual cash

transfers that are insufficient to cross the minimum-viable-area threshold when applied to holdings of 0.2–0.3 ha^[6, 12].

Conclusion

The main contribution of this research is a holding-size-disaggregated analysis of land-use transition and livelihood vulnerability in the Kumaun Himalaya. Supporting evidence demonstrates that marginal holders experience qualitatively different transition dynamics faster abandonment, deeper income loss, and more rapid conversion to irreversible forest regrowth than their larger-holding neighbours. For the field of development economics, the identified 0.5 ha threshold below which complete abandonment odds exceed 50% provides a concrete screening criterion for targeting protective interventions. Open questions remain around the institutional feasibility of terrace cooperatives, the willingness of scattered marginal holders to pool land management, and whether micro-credit for high-value horticulture can generate returns sufficient to cross the viability threshold on holdings that are currently below it. Additionally, the ecological implications of the cultivation-to-forest transition deserve attention: while forest regrowth is broadly positive for carbon sequestration and slope stability, it represents an irreversible land-use change that forecloses future agricultural options, and the species composition of regrowth (predominantly chir pine in Kumaun) may not deliver the same ecosystem service profile as the broadleaf forests that originally occupied these slopes before terrace construction centuries ago.

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References

1. Tiwari PC, Joshi B. Natural and socio-economic factors affecting food security in the Himalayan headwaters. *Food Secur.* 2012;4(2):195–207.
2. MacDonald D, Crabtree JR, Wiesinger G, Dax T. Agricultural abandonment in mountain areas of Europe. *J Environ Manag.* 2000;59(1):47–69.
3. Negi GCS, Samal PK, Kuniyal JC. Declining agricultural productivity and its implications for hill farming. *Mountain Res Dev.* 2018;38(2):134–142.
4. Semwal RL, Nautiyal S, Sen KK, Rana U, Maikhuri RK. Patterns and ecological implications of agricultural land-use changes in central Himalaya. *Agric Ecosyst Environ.* 2004;102(1):81–92.
5. Uttarakhand Directorate of Economics and Statistics. District statistical handbook: Almora 2022. Dehradun: Government of Uttarakhand; 2023.
6. Mishra A, Agrawal NK, Thorup-Kristensen K. Livelihoods and adaptation in the mountain regions of the Hindu Kush Himalaya. *Environ Sci Policy.* 2017;78:68–73.
7. Rawat JS, Kumar M. Monitoring land use/cover change using remote sensing and GIS: a case research of Hawalbagh block. *Egypt J Remote Sens Space Sci.* 2015;18(1):77–84.
8. IPCC. Climate change 2014: impacts, adaptation, and vulnerability. Contribution of Working Group II. Cambridge: Cambridge University Press; 2014.
9. Joshi PC, Khulbe S, Kalkundiya A. Climate change and its impacts on agricultural landuse and migration in Almora district of Uttarakhand: research from Salt and Bhikiyasain blocks. *Int J Geogr Geol Environ.* 2024;6(2):187–194.
10. R Core Team. R: a language and environment for statistical computing. Vienna: R Foundation; 2023.
11. Tiwari PC, Joshi B. Environmental changes and sustainable development of water resources in the Himalayan headwaters. *Water Resour Manag.* 2012;26(4):883–907.
12. Scoones I. Livelihoods perspectives and rural development. *J Peasant Stud.* 2009;36(1):171–196.
13. Xu J, Grumbine RE, Shrestha A, Eriksson M. The melting Himalayas: cascading effects. *Conserv Biol.* 2009;23(3):520–530.
14. Dimri AP, Dash SK. Wintertime climatic trends in the western Himalayas. *Clim Change.* 2012;111(3–4):775–800.
15. Krishnan R, Shrestha AB, Ren G. Unravelling climate change in the Hindu Kush Himalaya. *Int J Climatol.* 2019;39(12):4794–4814.
16. Pande VC, Kurothe RS, Singh HB. Soil and water conservation for sustaining hill agriculture. *Indian J Soil Conserv.* 2019;47(1):34–41.
17. Bhandari P, Ghimire D. Rural agricultural change and individual out-migration. *Rural Sociol.* 2016;81(4):572–600.
18. Pepin N, Bradley RS, Diaz HF. Elevation-dependent warming in mountain regions. *Nat Clim Change.* 2015;5(5):424–430.