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PRIORITIZING CONSTRAINTS IN HILL AGRICULTURE IN ALMORA, KUMAON HIMALAYA, UTTARAKHAND: A GARRETT RANKING ANALYSIS

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Abstract

Hill agriculture remains the backbone of rural livelihoods in the Kumaon Himalaya but is hampered by interconnected economic, infrastructural, technological, environmental, and market access barriers that depress productivity and incomes. This study employs a descriptive-analytical design in the Almora district (Kumaon, Uttarakhand), surveying 100 farm households to profile socio-economic characteristics and prioritize constraints using the Garrett ranking technique, a widely applied method for ordinal constraint analysis in agricultural research. Respondents are predominantly young smallholders with modest landholdings and high dependency ratios, reflecting the structural realities of mountain farming systems in the region. Across five domains, the top-ranked constraints are dependence on traditional, low-value crops (economic), poor road connectivity and inadequate input access and storage (infrastructural), reliance on traditional knowledge and limited mechanization (technological), severe soil erosion and water scarcity (environmental), and inadequate transportation facilities and middlemen dependence (marketing), consistent with wider Himalayan evidence on terrain-induced frictions and climate vulnerability. Environmental stressors, including erosive slopes, variable hydrology, and cryosphere-linked irrigation fragility, compound risk exposures and reduce resilience under climate change. Policy implications include first-mile connectivity and local aggregation with cold-chain, watershed and spring-shed programs, and hill-suitable mechanization and extension for diversification into higher-value, climate-resilient portfolios. Strengthening farmer collectives and market infrastructure can improve price discovery, reduce intermediation, and enable quality-led participation in premium value chains for hill crops.

Keywords: Hill agriculture; Kumaon Himalaya; Almora district; Garrett ranking; agricultural constraints; mountain livelihoods.

Introduction

Agricultural development represents a widely recognized strategy for improving the quality of life in rural areas of developing nations. Enhanced agrarian productivity contributes to multiple development goals, including food security, raw material supply, income generation, employment creation, poverty reduction, industrial growth, rural-to-urban migration control, expansion of educational access, reduction in fertility rates, and improvement in women's social status. However, agriculture in difficult terrains has consistently underperformed despite its critical importance. Cultivators in mountainous regions face numerous socio-economic challenges, and their poor quality of life has significant social, political, financial, and ecological implications. Addressing agricultural constraints in hilly terrains has become increasingly urgent, as alternative economic activities such as animal husbandry or non-agricultural enterprises cannot substitute for viable agriculture in these regions.

Agriculture is essential for human survival, originating from early human settlements and the utilization of accessible animal and plant resources (Saxena et al. 2005). This sector is crucial for economic growth at both the individual and national levels. In India, agriculture is the main livelihood for about 58 percent of the population and makes the country the world's second-largest farm producer (Sinha and Sharma 2019).

The Indian Himalayan region supports a substantial population heavily dependent on subsistence farming practiced on marginal rainfed and irrigated farmlands (Tuteja 2013). Agriculture remains the economic mainstay of Uttarakhand's hill regions, located in the Central Himalayas (Lohani et al. 2023). With 86.07 percent of its total geographical area classified as hilly terrain, the state comprises two administrative divisions- Garhwal and Kumaon, eight geographical regions, and four agroclimatic zones (Rawat et al. 1996; Government of Uttarakhand, 2012; Singh, 2025). Agricultural production primarily depends on natural precipitation (Pant, 2002), with terraced fields relying entirely on seasonal rainfall in most areas, though some locations have inadequate irrigation systems (Negi and Pant, 1994).

Constraints in Hill Agriculture

Hill agriculture faces inherent constraints, including remoteness, inaccessibility, marginality, fragility due to moisture stress, poor soil conditions, and abbreviated growing seasons (Pratap, 2011). Despite higher cropping intensity, the Kumaon Himalayan region confronts numerous physical constraints beyond those mentioned above. Socio-economic challenges compound these difficulties, encompassing small landholdings, low productivity, inadequate production management, labor shortages, poor post-production management, deficient marketing networks, predominance of unirrigated land, and lack of entrepreneurship (Devi et al., 2020). This study employs the Garrett ranking method to identify and analyze constraints affecting hill agriculture in the Kumaon Himalaya.

Review of Literature

The literature on agricultural constraints encompasses diverse aspects and methodological approaches across different geographical contexts.

Jaiswal et al. (2018) investigated constraints faced by women in Chhattisgarh's agricultural sector, emphasizing the necessity for structured strategic plans addressing technical and economic challenges to facilitate farm women's growth and development.

Sumi and Rajkumar (2018) utilized the Garrett ranking method to examine constraints limiting ICT adoption among farmers in Nagaland's Dimapur district. Their findings identified insufficient awareness of information sources, inadequate ICT operational knowledge and skills, poor socio-economic status, and negative attitudes toward technology as primary barriers.

Ao and Jamir (2020) applied the Garrett ranking method to identify significant constraints in bamboo cultivation across Nagaland.

Begna (2020) synthesized key constraints limiting agricultural productivity in developing countries, including limited access to improved seeds, low profitability, insufficient seed multiplication capacity, inadequate irrigation infrastructure, poor transportation networks, and restricted market access—all contributing to reduced farmer profitability.

Debahash and Dubey (2021) examined contract farming constraints, determining that price fluctuations creating difficulties in establishing contract prices represented the most prominent challenge for sponsors.

Kumari and Chauhan (2021) employed Garrett ranking to identify constraints in cash crop cultivation in Himachal Pradesh's Sirmour district, revealing high input costs, inadequate scientific storage facilities, and adverse weather conditions during harvest as major limiting factors.

Kandpal (2022) conducted a Garrett ranking study among Uttarakhand mushroom cultivators, concluding that marketing problems, transportation facility deficits, and technical knowledge gaps constituted the primary constraints.

Asegie et al. (2022) applied Garrett ranking analysis to chickpea-growing farmers, identifying untimely improved seed supply, short supply and high input costs, productive resource shortages, pest and disease pressures, and limited in-kind credit access as the most significant constraints affecting smallholder production.

Kolekar et al. (2024) explored constraints affecting farm and non-farm members using Garrett ranking, identifying coordination deficits, information gaps, and credit facility limitations as principal barriers.

Nandini and Vekanramanna (2024) highlighted financial constraints as significant impediments to climate-smart agricultural technology adoption.

The reviewed literature demonstrates widespread application of the Garrett ranking methodology for constraint identification across various agricultural contexts. However, a research gap exists regarding comprehensive constraint analysis in the Kumaon region's hilly terrain. The present study addresses this gap by examining constraints in the Almora district, contributing to understanding agricultural challenges in this mountainous area.

Extant scholarship underscores persistent physical and socio-economic constraints in Himalayan hill agriculture, yet comprehensive, district-level analyses remain limited for the Kumaon region. Accordingly, **the present study addresses this gap by examining constraints in the Almora district to advance context-specific understanding of agricultural challenges in mountainous**

environments. Specifically, it seeks to **identify and analyze the social, economic, and ecological challenges faced by farmers in Kumaon, with a focus on constraints in agricultural productivity and sustainability.**

Research methodology

The empirical study adopts a descriptive–analytical design to characterize respondents' socio-economic profiles and to prioritize production constraints using an established ordinal ranking approach widely applied in agricultural research. Fieldwork was undertaken in the Almora district in the Kumaon hills of Uttarakhand, a mid-Himalayan setting where agriculture is central to rural livelihoods and is exposed to terrain-induced constraints. The sample comprises 100 respondents selected through probability-based simple random sampling, while the study site was chosen purposively to reflect the hill-agriculture context under investigation, aligning with common designs in constraint-analysis studies. Primary data were collected via personal interviews using a structured interview schedule, complemented by secondary information from published sources to contextualize agro-ecological and socio-economic conditions in the region.

Research design

The design is descriptive in profiling households and analytic in assessing and ranking constraints, consistent with prior agricultural studies that combine summary statistics with structured prioritization methods to derive actionable insights for hill regions. Almora's mid-Himalayan location within Kumaon provides a relevant setting to examine terrain-related and institutional factors shaping agricultural practices and constraints in mountain agriculture. A total of 100 respondents were drawn by simple random sampling from the target population to ensure unbiased inclusion, while purposive selection of Almora enabled depth of inquiry in a representative hill district, mirroring sampling choices in comparable constraint-focused studies.

Study location

Almora district is situated in the Kumaon Himalaya of Uttarakhand, characterized by rugged topography, dispersed settlements, and traditional agricultural systems that remain foundational to livelihoods in the hills. The regional economy continues to rely heavily on smallholder farming and allied activities, with climatic variability and market access shaping production choices and household well-being. This context provides an appropriate empirical setting for analyzing constraints to productivity and sustainability in hill agriculture.

Analytical tools

Descriptive statistics, specifically simple percentages and arithmetic means, were used to summarize respondents' socio-economic characteristics and farming attributes in a transparent and replicable manner. To prioritize constraints affecting agricultural production, the study employed the Garrett ranking method, a widely used technique in Indian and international agricultural research to convert ordinal rankings into comparable scores for robust aggregation and ranking. The choice of Garrett ranking is consistent with recent empirical applications that assess constraint severity and inform context-specific recommendations for production systems.

Garrett ranking technique

Respondents assigned ranks to identified constraints, which were then transformed into percent positions using the standard Garrett formula, ensuring consistent conversion of ordinal data into quantitative scores for analysis. The percent position for the ith item ranked by the jth respondent is given by:

Percent Position = 100 (Rij -0.50)/ Nij

Where, Rij = Rank given to the i^{th} item by the jth individual, Nij = Number of items ranked by the j^{th} individual, following the original formulation and subsequent methodological guides. Each percent position was mapped to a Garrett score using the tabulated conversion values, and the individual scores for each constraint were summed across respondents to obtain a total score per constraint. Mean scores were then computed for each constraint, and final priority ranks were assigned by ordering constraints from the highest to the lowest mean score, with rank 1 indicating the most critical constraint for intervention.

Results and discussion

Socio-economic status of respondents

Socio-economic status (SES) reflects an individual or household's relative position within society based on a composite of social and economic attributes (Roy et al., 2013). In this study, SES was profiled using the following variables: social category, age, education, occupation, landholding status, farming experience, and annual income. The average age of respondents was 37.82 years, indicating a predominantly young cohort, with the highest concentration in the 28–38 age group. Caste composition shows 35.1 percent of respondents from the Scheduled Caste and the remainder from the General category. All respondents were married. Educational attainment indicates 31.03 percent with higher secondary or above, followed by 27.58 percent up to the primary level.

Family structure analysis shows 75.86 percent in nuclear households, with an average family size of 5.63 members; 89.6 percent reported three or more dependents. Regarding economic status, the average operational holding was 30 nali (approximately 0.6 ha), and all respondents reported ownership of a pucca ancestral house. The mean number of earning members per household was 2, while the average farming experience stood at 12 years. These features collectively depict smallholder households with modest land resources, multi-dependency, and relatively young agricultural operators commonly observed in hill agrarian settings where labour sharing, subsistence orientation, and off-farm income co-exist.

Constraints overview

To structure the analysis, constraints were organized into five domains: economic, infrastructural, technological, environmental, and marketing and prioritized using the Garrett ranking method. A total of 35 constraints were examined. The ranked top three constraints within each domain are summarized below, followed by interpretive discussion.

Across domains, the Garrett ranking highlights a consistent pattern of binding constraints in Almora's hill agriculture: economically, dependence on traditional, low-value crops is most salient, followed by high transportation costs and weak price realization; infrastructurally, poor road connectivity leads, with limited access to inputs and inadequate storage and cold-chain capacity close behind; technologically, reliance on traditional knowledge dominates, trailed by

restricted mechanization and insufficient research and development support; environmentally, soil erosion is paramount, with water scarcity and inadequate irrigation, then climate-change vulnerability, intensifying production risk; and in marketing, inadequate transportation facilities are most constraining, ahead of dependence on middlemen and limited access to support prices, together delineating a terrain where thin markets, fragile ecologies, and infrastructural deficits jointly depress productivity and farm incomes.

Table 1A. Economic constraints- Garrett ranking

Constraint	Mean score	Rank
Dependence on traditional crops	56.17	I
High transportation costs	55.40	II
Low price realization	54.67	III

Table 1B. Infrastructural constraints- Garrett ranking

Constraint	Mean score	Rank
Poor road connectivity	59.81	I
Lack of access to agricultural inputs	56.30	II
Limited storage and cold chain facilities	54.76	III

Table 1C. Technological constraints- Garrett ranking

Constraint	Mean score	Rank
Dependency on traditional knowledge	60.94	I
Limited access to mechanization	56.16	II
Insufficient R&D support	55.93	III

Table 1D. Environmental constraints- Garrett ranking

Constraint	Mean score	Rank
Soil erosion	59.61	I
Water scarcity and inadequate irrigation	58.51	II
Climate change vulnerability	57.43	III

Table 1E. Marketing constraints- Garrett ranking

Constraint	Mean score	Rank
Inadequate transportation facilities	58.13	I
Dependence on middlemen	57.87	II
Limited access to support prices	56.49	III

Source: Primary survey (N = 100).

Economic constraints

Economic barriers are driven by low-value crop portfolios, high logistics costs, and weak price transmission. The top-ranked constraint dependence on traditional crops reflects subsistence-oriented choices with limited market value-add, constraining cash flows and perpetuating low-

investment equilibria. High transportation costs further compress net margins due to difficult terrain, small volumes, and fragmented logistics. Low price realization indicates weak bargaining power, thin local markets, and quality/grade mismatches, often exacerbated by perishability and lack of collective marketing.

Infrastructural constraints

Infrastructure deficits amplify mountain-specific transaction costs. Poor road connectivity limits timely access to markets, inputs, and services, and raises post-harvest losses and opportunity costs. Insufficient access to inputs constrains the adoption of improved seed, nutrient, and plant protection protocols, locking farmers into low-input, low-output regimes. Limited storage and cold chain reduce producer surplus by forcing distress sales and constraining participation in remunerative value chains; complementary gaps include irrigation assets, post-harvest facilities, and extension reach.

Technological constraints

Technology gaps suppress productivity growth and resilience. Reliance on traditional knowledge signals limited diffusion of improved practices, precision agronomy, and climate-smart methods. Restricted access to mechanization reflects small, terraced fields, capital constraints, and service gaps (e.g., custom hiring). Insufficient R&D support, especially adaptive, location-specific research, limits the pipeline of viable hill technologies and hampers the uptake of innovations suited to fragmented holdings and rugged topography.

Environmental constraints

Environmental stresses are structural in hill systems. Soil erosion is the most severe constraint, driven by slope, intense rainfall events, and degraded vegetative cover, undermining soil depth, fertility, and moisture retention. Water scarcity and inadequate irrigation reflect high spatiotemporal variability in precipitation and limited storage/conveyance capacity. Climate change vulnerability compounds risk through shifting seasons, extreme events, and pest/disease pressures, interacting with fragile ecosystems and land-use change.

Marketing constraints

Market access frictions depress farmgate returns. Inadequate transportation facilities limit frequency, reliability, and cost-efficiency of market trips, translating into reduced competitiveness and higher wastage. Middlemen dependence persists due to information asymmetries, scale disadvantages, and working capital needs, often resulting in adverse terms of trade. Limited access to support prices (e.g., MSP or state schemes), sparse market infrastructure, and irregular market intelligence further weaken price discovery and farmer agency.

Limitations of the study

- The study is confined to respondent farmers in Almora district, limiting external validity across heterogeneous Himalayan contexts.
- Respondents may face difficulty distinguishing and ranking closely related constraints, introducing ranking noise and response bias.

Few Suggestions

The following targeted policy actions can directly address the economic, infrastructural, technological, environmental, and marketing constraints observed in Almora's hill agriculture.

1. **Reduce logistics and market frictions**
   - Upgrade all-weather road connectivity to farm gates and local mandis, and establish village-level aggregation, grading, packhouses, and cold-chain units to cut transport losses and enable remunerative sales.
   - Strengthen farmer-producer organizations and cooperative marketing to reduce dependence on middlemen, improve price realization, and facilitate access to MSP and e-market linkages.
   - Organize scheduled first-mile collection services so dispersed smallholders can pool volumes and lower per-unit transport costs.
2. **Build soil and water resilience at the watershed scale**
   - Finance watershed and spring-shed programs, contour trenching, check dams, terrace rehabilitation, and rainwater harvesting to curb erosion and improve base flows for irrigation.
   - Scale micro-irrigation and water-efficient agronomy, complemented by localized climate advisories, to buffer rainfall variability and reduce production risk.
   - Incentivize agroforestry and vegetative cover on slopes to stabilize soils while diversifying household incomes.
3. **Deploy hill-suitable technology and diversification**
   - Establish custom hiring centers for light mechanization adapted to terraces, coupled with last-mile input delivery, repair services, and on-farm demonstrations.
   - Invest in adaptive R&D and extension for high-value hill crops and local landraces, ensuring timely access to quality seed and planting material to shift away from low-value traditional portfolios.
   - Provide blended digital and in-person training on climate-smart practices and post-harvest management to raise productivity and reduce losses

Conclusion

Hill agriculture in the Kumaon Himalayas continues to underpin rural livelihoods but is constrained by mutually reinforcing economic, infrastructural, technological, environmental, and marketing barriers that suppress productivity and household incomes. Garrett-based prioritization in this study highlights actionable levers: gradual diversification from low-value traditional crops toward high-value, climate-resilient portfolios; first-mile connectivity and aggregation to compress logistics costs; timely access to quality inputs supported by adaptive, last-mile extension; soil and water conservation to curb erosion and water stress; and stronger market systems through storage, grading, price information, and collective marketing. Translating these levers into outcomes will require targeted public investment in all-weather rural roads, decentralized cold-chain and packhouses, micro-irrigation and spring-shed development, and custom hiring centers for hill-suitable mechanization. Parallel community-led resource management and watershed programs can stabilize slopes, reduce sediment loss, and enhance base flows, while

region-specific extension and R&D catalyze adoption of climate-smart practices and hill-adapted varieties responsive to changing climatic risks. Strengthening farmer-producer organizations and cooperatives can improve price discovery, reduce intermediation, and enable scale in procurement, processing, and market access, particularly for fruits, spices, and other niche hill crops that command premiums when quality and cold-chain integrity are assured. With sustained policy attention, capacity building, and rigorous monitoring tailored to Almora's terrain and socio-economic realities, these interventions can raise farm productivity, stabilize incomes, and enhance the long-term sustainability and resilience of hill agriculture in the Kumaon region.

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