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# REGIONAL DISPARITIES IN MEDICINAL AND AROMATIC PLANTS (MAPs) IN UTTARAKHAND, INDIA: INSIGHTS FROM DEHRADUN, HARIDWAR AND TEHRI GARHWAL

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**ABSTRACT**

Uttarakhand, endowed with rich biodiversity and varied agro-climatic conditions, holds significant potential for the cultivation of Medicinaland Aromatic Plants (MAPs). This study investigates the adoption levels, land holding capacity and economic returns of MAPs across three ecologically diverse districts-Dehradun, Haridwar and Tehri Garhwal. Field surveys conducted across a broad set of villages and farming communities reveal considerable regional disparities. Dehradun reflects the highest rate of adoption, Haridwar excels in land utilization and profitability, while Tehri Garhwal, despite a wide variety of crops, shows relatively limited uptake. Economic analysis confirms the profitability of crops such as turmeric, ginger and aloe vera, especially were supported by robust infrastructure and market access. However, several constraints including low awareness, inadequate institutional support, fragmented landholdings and limited market integration impede large-scale adoption. the study underscores the need for targeted policy interventions, enhanced market linkages, farmer education and sustainable practices. Policy recommendations, innovative technologies, and strategic capacity-building initiatives are proposed to optimize the AP value chain and uplift the livelihoods of local farming communities.

***Key words :*** Medicinal and Aromatic (MAP), Uttarakhand, Adoption rate, Economic returns, Land utilization, Regional disparity.

## Introduction

Medicinal and Aromatic Plants (MAPs) have gained global significance due to their extensive applications in healthcare, cosmetics, wellness and sustainable agriculture. India stands as the third-largest producer of essential oils, contributing 16-17% of global production, and is the second-largest exporter of medicinal plants after China, collectively catering to over 70% of the global herbal demand (GoU, 2019). With diverse agro-climatic zones and a rich heritage of traditional medicinal knowledge, India holds immense potential for MAP cultivation. In particular, the Himalayan state of Uttarakhand offers unique prospects due to its varied altitudinal ranges, soil diversity and favourable climatic conditions (Sanwal *et al*., 2011; Sundriyal and Sharma, 2016).

Despite its advantages, the adoption and scale of MAP cultivation in Uttarakhand remain limited. The state's hilly terrain and marginal farming conditions offer both opportunities and constraints. The Government of India has recognized the importance of this sector, launching dedicated initiatives such as the Aroma Mission and National AYUSH Mission, and institutions like the State Medicinal Plant Board (SMPB-Uttarakhand), Centre for Aromatic Plants (CAP), which provide financial support, training and marketing, awareness campaigns and technological assistance to farmers (GoI, 2018). However, uneven dissemination of resources, low farmer awareness, inconsistent market linkages, andinfrastructural deficits have hindered large-scale adoption and profitability (Mishra *et al*., 2022 and Kapoor *et al*., 2021).

Previous studies have emphasized both the ecological and economic potential of MAPs in the Himalayan region. Nautiyal and Nautiyal (2004), Thakur *et al*. (2019) underscored the economic importance of MAPs while cautioning against threats such as overharvesting and habitat degradation. Similarly, researchers such as Hasan *et al*. (2006) and Yadav *et al*. (2013) documented the agro- ecological suitability of MAPsand the constraints faced by cultivators. Policy analyses by the KIT Royal Tropical Institute (2004) and Choudhary *et al*. (2013a, 2013b) highlighted the need for robust institutional frameworks and trade dynamics in Uttarakhand to enhance MAPs commercial viability.

The present study builds on this body of research by examining the adoption trends, land utilization patterns, economic returns and value chain dynamics of MAPs cultivation across three districts of Uttarakhand: Dehradun, Haridwar and Tehri Garhwal. These districts represent diverse altitudes, climatic zones and socio-economic structures, offering a comprehensive lens through which to assess the regional variations in MAPs adoption. According to field surveys, MAPs adoption in these regions ranged from 16% in Tehri Garhwal to 30.25% in Dehradun, highlighting significant spatial disparities that warrant targeted intervention.

Economic analyses conducted during the study reaffirm the profitability of key MAPs crops such as turmeric, ginger and aloe vera, particularly when supported by adequate infrastructure and market access (Bhatt and Singh, 2019; Sharma *et al*., 2020; Gupta *et al*., 2018). However, farmers continue to face numerous challenges including high input costs, non-uniform pricing, limited access to certification processes and insufficient government subsidies. Value chain analysis reveals gaps in processing, marketing and stakeholder collaboration, emphasizing the need for a more integrated approach and critical to enhancing farmer participation and profitability.

The paper aims to address these challenges by identifying socio-economic and technical factors influencing MAPs adoption andproposingevidence-basedstrategies to strengthen the value chain. Through a comparative analysis of cultivation practices and economic outcomes across Dehradun, Haridwar and Tehri Garhwal, the study contributes to the broader discourse on sustainable agriculture and rural development. By integrating traditional with modern agricultural practices and institutional support, MAPs cultivation in Uttarakhand holds the potential to emerge as a transformative force for economic upliftment and global herbal trade.

This study seeksto conduct a comparative analysis of MAPs cultivation across Dehradun, Haridwar and Tehri Garhwal, focusing on adoption rates, land utilization, economic returns and regional disparities to identify challenges and opportunities for enhancing MAP-based agriculture in Uttarakhand.

## Materials and Methods

### Study area

The study was conducted in three districts of Uttarakhand: Dehradun, Haridwar and Tehri Garhwal each representing diverse agro-climatic conditions and socio-economic characteristics (Fig. 1). Together covering approximately 13,086 km$^2$, these districts offer an ideal setting for the cultivation and value chain analysis of ecologically and economically significant MAPs. These regions reflect Uttarakhand's rich biodiversity, traditional herbal practices, and potential for sustainable MAP-based rural development.

Dehradun, located in the Doon Valley, serves as a research and trade hub for MAPs. It features a humid subtropical to temperate climate with annual rainfall of around 2,000 mm and temperatures ranging from 3°C to 35°C. The district comprises six tehsils and six Community Development blocks (CDBs), with 746 inhabited villages (Census of India, 2011). Haridwar, located in the Gangetic Plains, covers an area of 2,360 km$^2$, is a key centre for Ayurveda and herbal industries. With a humid subtropical climate and an average rainfall of 1,200mm, it includes three tehsils and six CDBs, comprising 623 inhabited villages (Census of India, 2011). Tehri Garhwal, situated in central Uttarakhand, is known for its high-altitude MAPs cultivation and traditional agroforestry. Spanning 4,080 km$^2$, it includes seven tehsils and nine development blocks, with 1,847 revenue villages and 2,508 clusters (Census of India, 2011).

### Dataset and adopted Methodology

A combination of primary and secondary data sources is used to ensure the reliability and validity of the study. Data were collected from multiple sources, and standardized research instruments (questionnaires, interview guides and data collection sheets) were employed to maintain consistency. This approach unbiased and error-free data collection across the different study regions. A survey of 1,200 farmers across 60 villages (20 villages per district) was conducted. Data included adoption rates, land utilization, crop types, economic returns and barrier faced by farmers.

The methodology consists of three major components: Survey Techniques, Assessment of MAPs, and Sampling

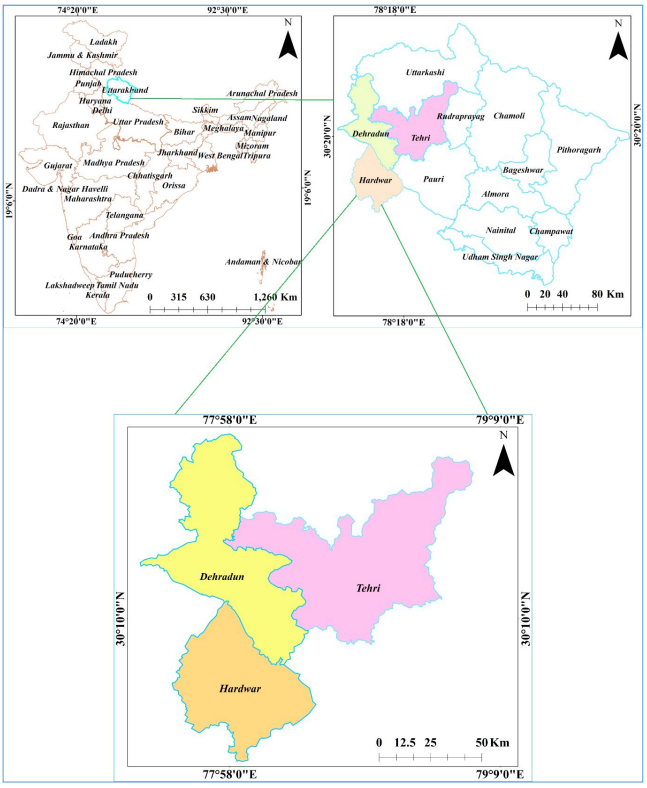


**Fig. 1 :** Location of the study area.

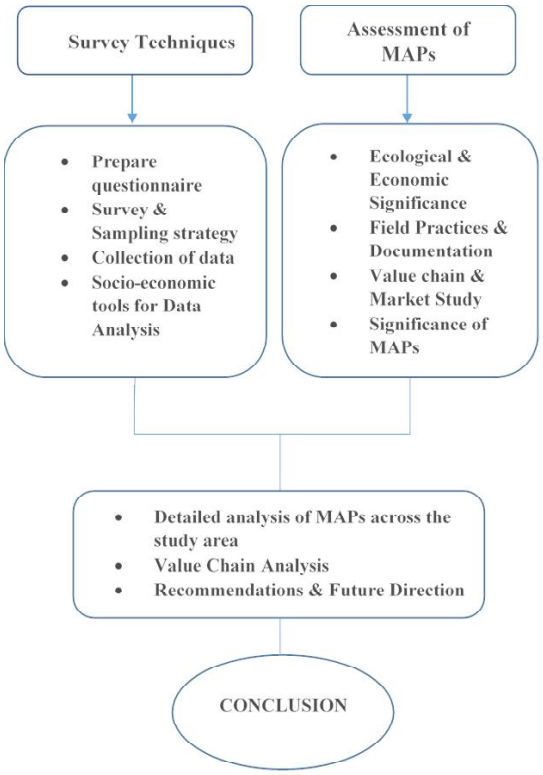


**Fig. 2 :** Methodology framework adopted for the study.

Method. Each component contributes to gathering, analysing, and interpreting data to reach meaningful conclusions. Fig. 2 represents the adopted methodology framework for the study.

## Results and Discussion

The comparative analysis reveals substantial disparities in MAPs adoption, land utilization, economic returns and crop diversity across the three districts. Haridwar leads in profitability and land utilization, while Dehradun demonstrates higher adoption rates. Tehri Garhwal, though lagging shows potential for growth with appropriate interventions Addressing challenges like market access, training and financial support can significantly enhance MAPs cultivation and its economic impact in these regions. Table 1 provides a brief idea about the distribution of adopted parameters (adoption rates, land utilization, dominant and unique crops, economic returns, benefit-cost ratios, challenges and market access) across the three districts.

### Adoption of MAPs Practices

**Dehradun :** The overall adoption rate of MAPs cultivation stands at 30.25%, with 121 out of 400 farmers actively participating (Fig. 3). Among the villages, Lelta exhibits the highest adoption rate (100%), while Kanswali recorded no adoption (0%), highlighting stark contrasts in participation. These disparities in adoption levels across villages suggest varying levels of awareness, infrastructure and suitability, necessitating targeted interventions to bridge the gap.

**Haridwar :** The overall adoption rate of MAPs cultivation stands at 27.25% with 109 out of 400 farmers engaged in the practice (Fig. 4). Among the villages, Gairabad leads with the highest adoption rate (50%), reflecting strong awareness and favourable conditions.

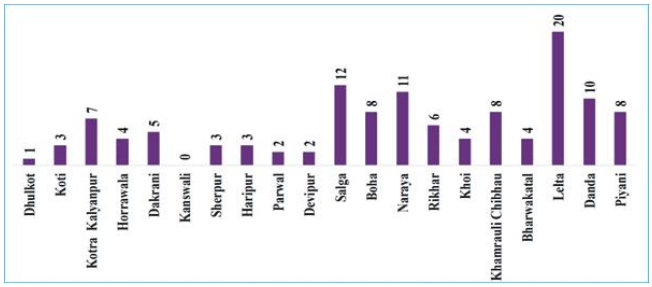


**Fig. 3 :** Representation of practicing MAPs across 20 different villages in Dehradun district.


**Fig. 4 :** Representation of practicing MAPs across 20 different villages in Haridwar district.

In contrast, Shayampur and Hadipur Grant report the lowest adoption rates (10%), indicating significant barriers such as limited resources or knowledge gaps. Villages like Gaindikhata, Pillipadaw, Shetlakheda (35%) and Salempur (40%) demonstrate moderate adoption levels, suggesting potential for growth with the right support and incentives.

**Tehri Garhwal :** The adoption rate of MAPs cultivation stands at 16% (63 out of 400 farmers), marking the lowest adoption rate among the three blocks studied (Fig. 5). Haleth and Godri recorded the highest adoption rates at 30% each, suggesting a relatively stronger inclination toward MAPs cultivation. On the other hand, Manjhgaon and Chaurareported zero adoption.

**Observation :** Dehradun shows the highest adoption rate, while Tehri Garhwal lags significantly, indicating the need for targeted interventions in awareness and capacity-building.

### Land Utilization for MAPs Cultivation

**Dehradun :** The land utilization data for Dehradun reveals that a total of 920.50 Ha of land has been surveyed (Fig. 6). Of this, only 27.47 Ha or 2.98% of the total landholdings is dedicated to the cultivation of MAPs. Among the areas surveyed, Salga, Danda and Lelta emerge as the highest contributors, with 7.05%, 6.96% and 6.13% of their respective lands utilized for this purpose. In contrast, Kanswali and Rikhar show minimal engagement in MAPs with Kanswali contributing 0% and Rikhar contributing only 0.99%.

**Haridwar :** The land utilization data for Haridwar indicates that a total of 1363.47 Ha of land has been surveyed, out of which 34.06 Ha, accounting for 2.50%


**Fig. 5 :** Representation of practicing MAPs across 20 different villages in Tehri Garhwal.

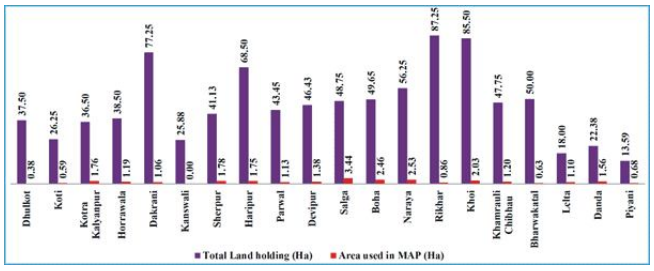


**Fig. 6 :** Total landholdings and area utilized for MAPs cultivations.

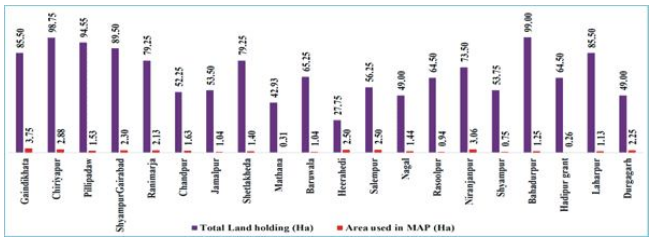


**Fig. 7 :** Total landholdings and area utilized for MAPs cultivations.

of the total landholdings, is dedicated to the cultivation of MAPs (Fig. 7). Among the surveyed areas, Heerahedi, Gaindikhata and Salempur emerge as the highest contributors, with 9.01%, 4.39% and 4.45% of their respective lands utilized for MAPs cultivation. Conversely, Mathana and Hadipur Grant show low contributions with only 0.73% and 0.41% of their land allocated to this practice.

**Tehri Garhwal :** The land utilization data for Tehri Garhwal revels that out of the total surveyed land of 1239.65 Ha, 18.93 Ha (1.53% of total landholdings) are allocated for the cultivation of MAPs (Fig. 8). Among the surveyed regions, Odorso, Haleth and Chakrera are the high contributors, utilizing 4.26%, 3.40% and 2.24% of their respective lands for MAPs cultivation. On the other hand, Uniyalgaon and Hadegi demonstrate minimal engagement, with only 0.59% and 0.40% of their lands dedicated to this practice.

**Observation:** Haridwar has the highest percentage of land allocated to MAPs cultivation, while Dehradun has the lowest. Tehri Garhwal shows potential for moderate improvement with targeted support.

### Areal Distribution of Crops

**Dehradun :** Fig. 9 illustrates the diverse cultivation of MAPs across various Dehradun district villages. Ginger and Turmeric emerge as the most dominant crops, with villages such as Salga, Boha, Naraya, Lelta and Dandashowing extensive cultivation, particularlySalga, which records the highest area under Turmeric at 2.44 Ha.Lemongrass is also widely cultivated, notably in Dakrani (1.06 Ha), Horrawala (0.69 Ha), and Devipur (0.88 Ha), while Aloe vera is concentrated in Sherpur (0.50) and Haripur and (1.50 Ha). Other crops like Indian basil, Bay leaf and Citronella are grown on more minor scales. Notably, Stevia is grown exclusively in Devipur (0.50 Ha), indicating a niche focus. Indian gooseberry has a limited presence in Kotra Kalyanpur, Horrawala and Salga. Kanswali reports no MAPs cultivation, highlighting localized gaps in adoption.

**Haridwar :** Fig. 10 presents a diverse pattern of MAPs cultivation across villages in Haridwar. Turmeric,

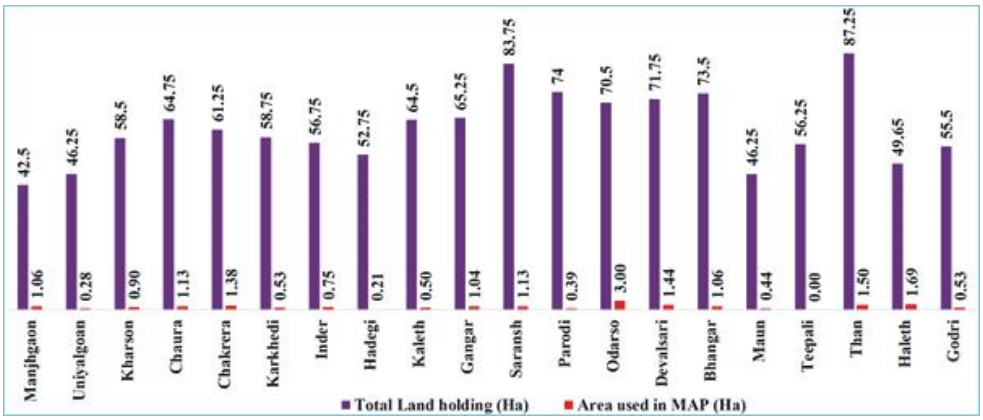


**Fig. 8 :** Total landholdings and area utilized for MAPs cultivation.

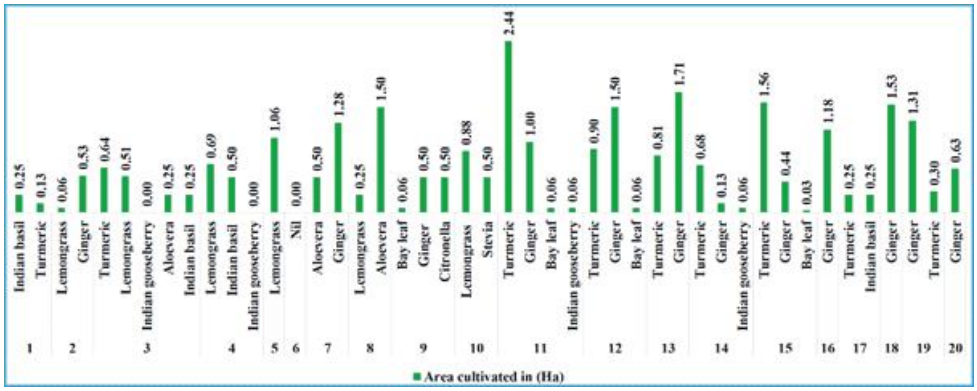


**Fig. 9 :** Areal distribution of various crops in the different villages within the Dehradun.

Ginger and Aloe vera emerge as the dominant crop, with Aloe vera occupying the highest area in Gaindikhata (2.25 Ha), while Ginger and Turmeric show a strong presence in Niranjanpur (1.75 Ha), Shyampur Gairabad (1.29 Ha), Salempur (1.25 Ha) and Nagal (0.99 Ha). Secondary crops like Lemongrass in Gaindikhata (1.13 Ha) and Heerahedi (0.75 Ha), benefiting from the region's suitability for aromatic plants, Stevia in Chiriyapur (0.50 Ha), Baruwala (0.50 Ha) and Jamalpur (0.50 Ha), reflecting its rising market demand and Mint in Salempur (0.63 Ha) and Chandpur (0.50 Ha) are cultivated in moderate areas, supporting crop diversification. These crops offer diversification opportunities for farmers, potentially enhancing overall profitability and sustainability.Unique Crops such as Damask Rosein Durgagarh (1.25 Ha), Shyampur Gairabad (0.75 Ha), and Salempur (0.50 Ha), for ornamental ornamental purposes and essential oil extraction. Little millet is limited to Mathana (0.13 Ha) and Rasoolpur (0.06 Ha). Curry leaves, cultivated exclusively in Shetlakheda (0.06 Ha) for culinary purposes. Indian lilac, found only in Shyampur Gairabad (0.01 Ha), is likely for ecological or medicinal purposes. Heart-leaved moonseed, used for medicinal purposes, is grown in Heerahedi (0.50 Ha) and Jamalpur (0.0 Ha). Oregano, with potential culinary and medicinal uses, is found in Hadipur Grant (0.13 Ha) and Durgagarh (0.25 Ha). However, the presence of non-cultivated or minimal cultivation crops like Indian gooseberry, Little millet and Stevia in certain villages points to regional disparities in adoption. Thissuggests the need for targeted interventions, to promote their adoption in suitable regions.

**Tehri Garhwal :** Fig. 11 outlines a distinct pattern of MAPs cultivation across villages in Tehri Garhwal, with a focus on both diversity and crop specialization. Villages like Manjhgaon, Karkhedi and Devalsari showcase a diverse cultivation portfolio, growing multiple crops:

Manjhgaon: Ginger (0.50), Turmeric (0.25), Indian basil (0.13), Lemongrass (0.13) and Asparagus (0.06).

Karkhedi: Indian lilac (0.01), Heart-leaved moonseed (0.06), Turmeric (0.06), Bay leaf (0.03), Oregano (0.13), and little millet (0.13).

Devalsari: Chamomile (0.06), Ginger (0.50), Turmeric (0.50), Indian basil (0.25) and Black cumin (0.13).

In contrast, villages such as Odarso (1.75 Ha), Than (1.31), and Haleth (1.00 Ha) are prominently focused on Ginger, indicating its economic importance and suitability to local conditions. Turmeric cultivation is notable in Chakrera and Odarso (0.88 Ha each), while Gangar reflects limited adoption (0.13 Ha). This variation highlights localised preferences and resource availability,

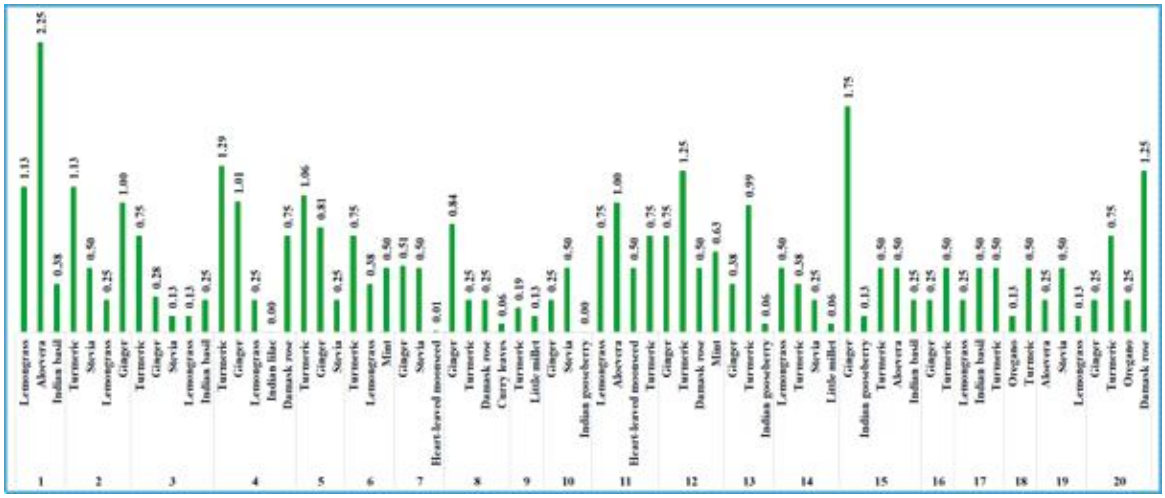

**Fig. 10 :** Areal distribution of various crops in the different villages within Haridwar.

**Table 1 :** Tabular analysis of several parameters of MAPs cultivation across the three districts.

| Parameter | Dehradun | Haridwar | Tehri Garhwal |
|---|---|---|---|
| Adoption Rate | 30.25% (121/400 farmers) | 27.25% (109/400 farmers) | 16.00% (63/400 farmers) |
| Land Utilization for MAPs | 27.47 Ha (2.98% of total land) | 34.06 Ha (2.50% of total land) | 18.93 Ha (1.52% of total land) |
| Dominant Crops | Ginger, Turmeric | Aloe vera, Turmeric | Ginger, Turmeric |
| Secondary Crops | Lemongrass, Mint | Stevia, Lemongrass | Black cumin, Asparagus |
| Unique Crops | Curry Leaves, Little millet | Damask Rose, Heart-leaved moonseed | Chamomile, Winged Prickly Ash |
| Economic Returns | High-profit crops: Turmeric, Aloe vera | High-profit crops: Turmeric, Lemongrass | High-profit crops: Ginger, Winged Prickly Ash |
| B: C Ratio (Best) | 2.27 (Indian gooseberry in Rikhar) | 3.68 (Lemongrass in Gaindikhata) | 3.04 (Winged Prickly Ash in Inder) |
| B:C Ratio (Worst) | 0.45 (Turmeric in Dhulkot) | 0.86 (Ginger in Shyampur) | 0.76 (Bay leaf in Haleth) |
| Challenges | Awareness gaps, market linkages, financial constraints | Pricing inconsistency, financial support gaps | Low awareness, lack of infrastructure |
| Market Access | Limited | Limited | Limited |
| Harvesting Practices | Manual | Manual | Manual |
| Supply Status | Bulk demand | Bulk demand | Bulk demand |

suggesting that targeted support and extension services can further enhance MAPs adoption and productivity in the region.

## Economic Returns and Benefit-Cost Ratios

**Dehradun :** The cost of cultivation for MAPs varies significantly across different crops and villages, with higher expenses often linked to crops like Ginger and Turmeric (Fig. 12). For instance, Ginger cultivation in Sherpur incurs a cost of ` 140,330, while Turmeric in Salga has the highest recorded cultivation cost of ` 414,001. However, these crops often yield high, making them economically viable despite the initial investment.

Turmeric emerges as the most profitable crop, with the highest gross return of ` 973,000 in Salga and a net return of ` 508,999. In contrast, its profitability is lower in Dhulkot, where the net return is only ` 14,030. Aloe vera shows moderate to high returns, with Haripur recording the highest net return of ` 243,910. Ginger is designated as one of the most widely cultivated and profitable crops. Non-profitable villages include Lelta: `

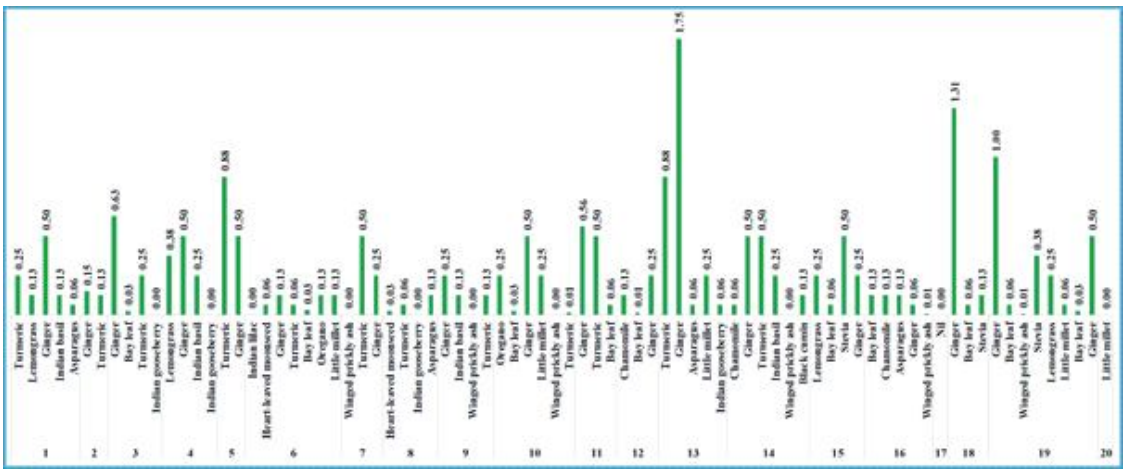

**Fig. 11 :** Areal distribution of various crops in the different villages within Tehri Garhwal.

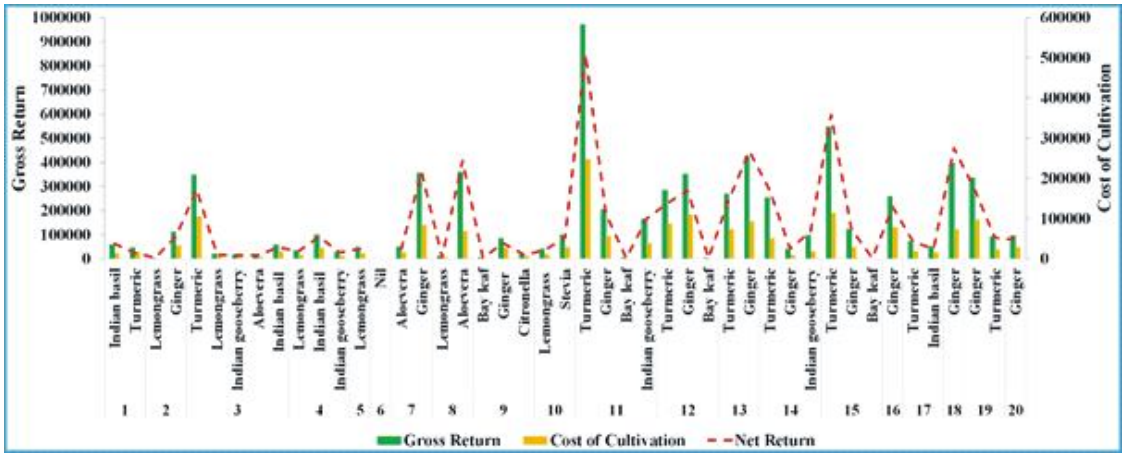


**Fig. 12 :** Distribution of Cost of cultivation, Gross Return and Net Return in the Dehradun district.

275,060 followed by Naraya: ` 268,310. Bay Leaf generally shows low profitability, with net returns ranging between ` 1,500 (Boha) and ` 3,150 (Parwal). Indian basil showed modest returns, with villages like Dhulkot and Bharwakatal yielding a net return of ` 37,228.5 and ` 24,730, respectively. Lemongrass showed moderate profitability with net returns like ` 24,250 in Dakrani and ` 21,200 in Devipur.

Benefit-Cost (B:C) ratio serves as a crucial measure of profitability, with values above 1 indicating profit and those below 1 suggesting a loss per unit of cost (Fig. 13). The profitability of MAPs crops varies significantly across different villages, with Indian gooseberry in Rikhar village recording the highest B:C ratio of 2.27, making it one of the most financially viable crops. In contrast, Turmeric in Dhulkot (0.45) and Lemongrass in Haripur (0.54) have lower B:C ratios, indicating limited profitability and financial risk. High B:C ratio crops, especially in Rikhar (` 68,000 net return) and Salga (` 99,660 net return), showcase strong financial returns. These variations underscore the importance of strategic crop selection and location-specific approaches to maximise profitability in MAPs cultivation.

**Haridwar :** The cost of cultivation varies significantly among crops, reflecting differences in input expenses incurred in producing the crops (e.g. seeds, fertilizers, labour and irrigation). Aloe vera in Gaindikhatahas a high cultivation cost of ` 70,500, reflecting its intensive management required, Lemongrass, in Laharpur requires only ` 3.050 for 0.13 Ha, making it a low-cost crop. In terms of gross returns, Turmeric in Chiriyapur generates ` 601,750 from 1.13 Ha, demonstrating high market demand. Similarly, Stevia in Ranimarja provides ` 60,000 from just 0.25 Ha, showcasing its profitability despite small-scale cultivation. However, net returns ultimately determine the crop's profitability for farmers. Turmeric in Shyampur Gairabad yields a high net return of[1] 254,025 from 1.29 Ha, confirming its economic viability. In contrast, Stevia in Pillipadaw results in just ` 26,350 from 0.13 Ha, indicating possible inefficiencies or market limitations that limit its profitability (Fig. 14).

Benefit-Cost (B:C) Ratio a key profitability indicator, varies significantly across different crops and villages.

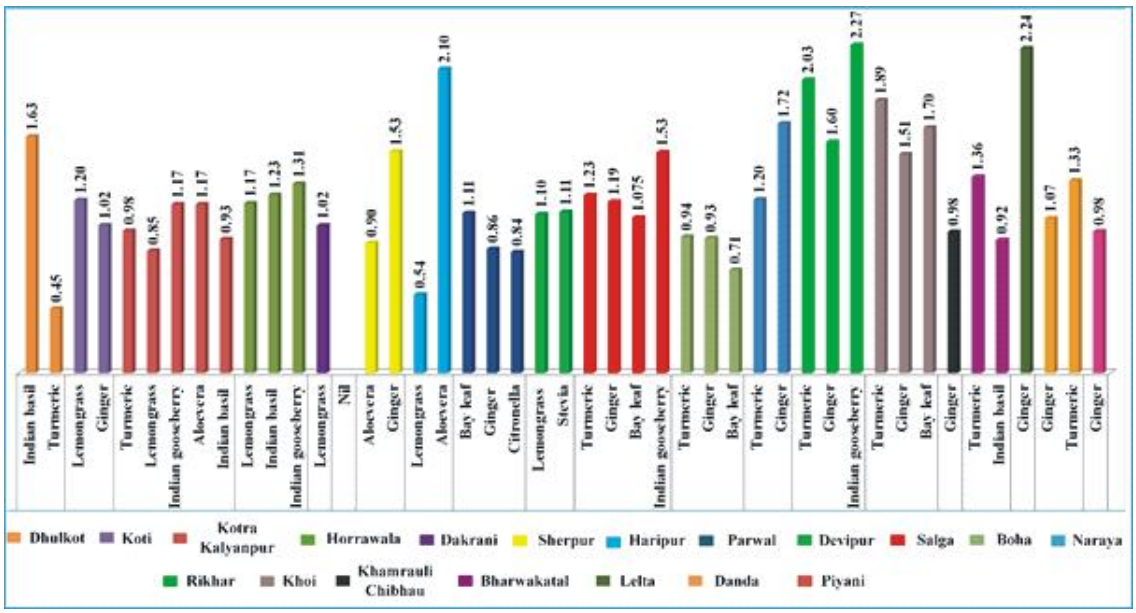


**Fig. 13 :** Calculated B:C ratio of different crops in different villages of the Dehradun district.

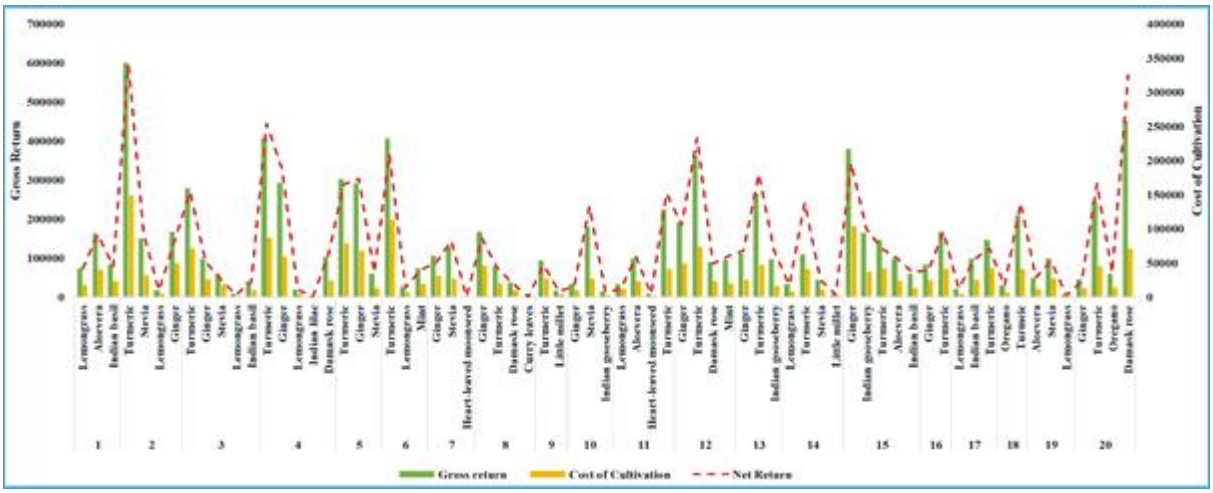


**Fig. 14 :** Distribution of Cost of cultivation, Gross Return and Net Return in the Haridwar district.

Lemongrass in Gaindikhata boasts the highest B:C ratio of 3.68, demonstrating exceptional profitability and efficient cost management. In contrast, Ginger in Shyampur has a ratio of 0.86, indicating losses or marginal returns, likely due to high input costs, lower market prices or suboptimal yields (Fig. 15). This variation highlights the importance of strategic crop selection, cost optimization and improved market access.

**Tehri Garhwal :** The cost of cultivation varies widely across crops and villages depending on the crop type, scale, labour, irrigation, cost of seeds and farming practices. Higher cultivation costs are often associated with crops like Turmeric and Ginger (Fig. 16). In Chakrera, the cost of cultivating Turmeric on 0.88 Ha is ` 2,36,950 followed by Ginger in Than which is cultivated on 1.31 Ha, showing the cost of cultivation of ` 1,49,100 while Heart-leaved moonseed in Hadegi which grown in 0.03 Ha shows least of ` 550. Overall, the total cost of cultivation across all villages amounts to ` 23,87,383, varying with crop type and land area.

In terms of gross returns, Turmeric in Chakrera generates the highest return at ` 4,74,500 from 0.88 Ha, while Heart-leaved moonseed in Hadegi, cultivated on 0.03 Ha, yields a modest ` 1,400. The total gross return across all villages and crops stands at ` 5,45,400.

The net returns, which determine actual profitability, follow a similar trend. Turmeric in Chakrera yields a net return of ` 2,37,550, while Ginger in Haleth, cultivated on 0.25 Ha, provides ` 1,48,520. Heart-leaved moonseed in Hadegi has the lowest net return of ` 850. Across all the villages and crops, the total net returns amount to ` 27,58,017 depending on the crop and area calculated.

In Inder, Winged Prickly Ash has the highest B:C

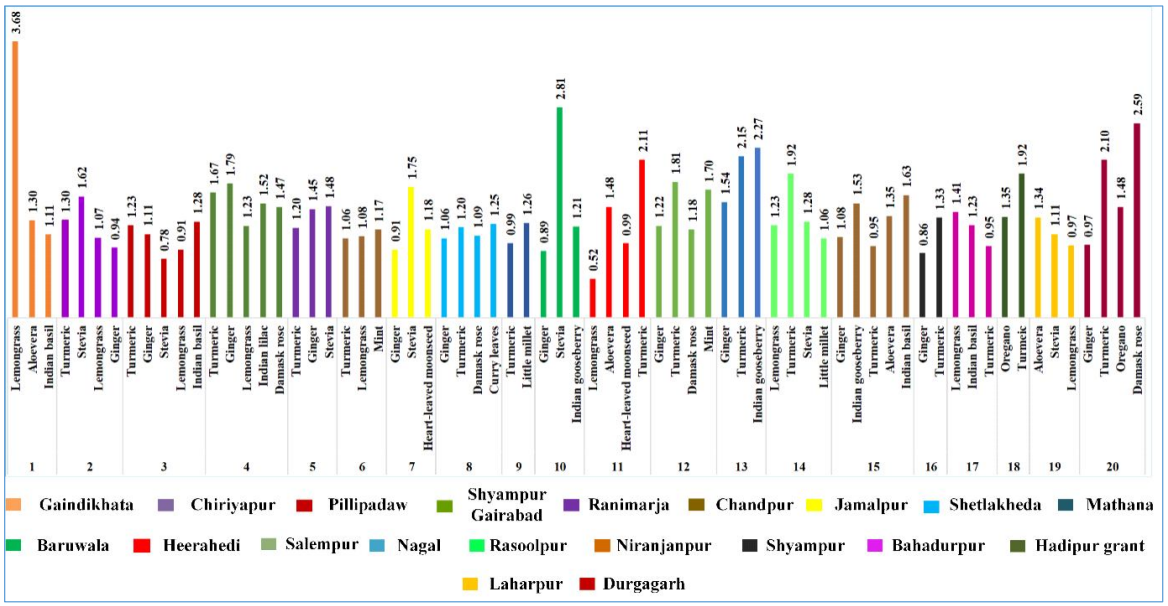


**Fig. 15 :** Calculated B:C ratio of different crops in different villages of the Haridwar district.

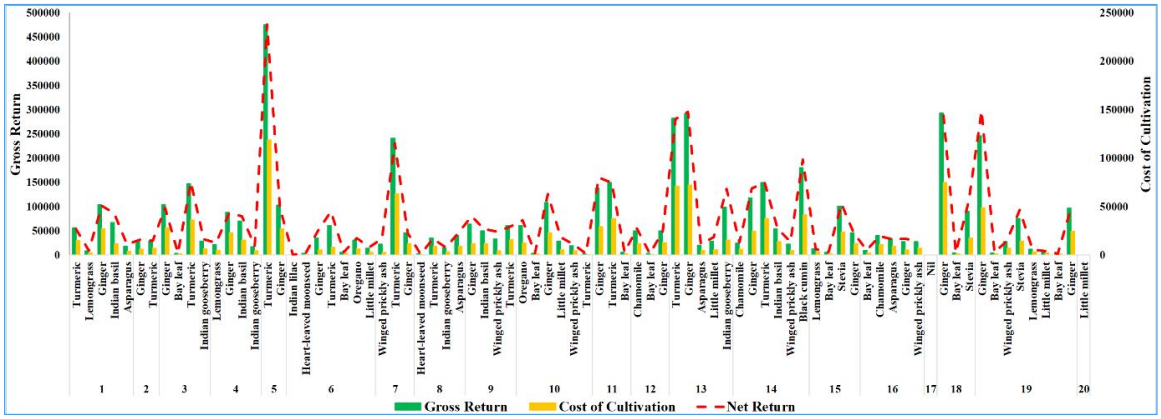


**Fig. 16 :** Distribution of Cost of cultivation, Gross Return and Net Return in the Tehri Garhwal.

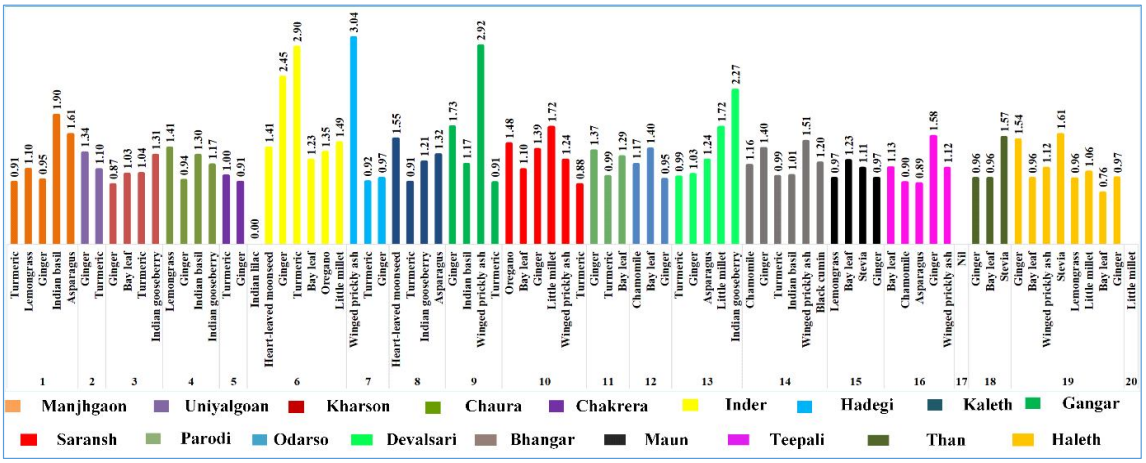


**Fig. 17 :** Calculated B: C ratio of different crops in different villages of the Tehri Garhwal.

ratio of 3.04, meaning ` 3.04 is earned for every rupee spent, highlighting its strong profitability (Fig. 17). Conversely, in Haleth, Bay Leaf has a B:C ratio of 0.76, indicating low economic efficiency and potential challenges in marketability or production costs. On average, crops such as Ginger, Indian basil and Stevia exhibit high B:C ratios, reinforcing their efficiency and economic viability across multiple villages.

**Regional disparities in MAPs cultivation: Challenges and Opportunities in Uttarakhand**

The study presents a clear picture of regional disparities in the adoption and cultivation of MAPs across Dehradun, Haridwar and Tehri Garhwal. These disparities stem from differences in topography, farmer awareness, market accessibility and institutional support.

Dehradun shows relatively higher adoption rates (30.25%), with villages like Salga and Lelta demonstrating full or significant engagement. Dominant crops include Ginger, Turmeric and Aloe vera, supported by better infrastructure, institutional proximity (e.g., Forest Research Institute andHerbal Research and Development Institute) and access to research and market networks. However, disparities exist even within the district- some villages like Kanswali report no MAPs cultivation, indicating the need for targeted awareness and training.

Haridwar presents a mixed scenario with a 27.25% adoption rate. While industrial linkages (e.g., Patanjali and SIDCUL) encourage the cultivation of Aloe vera, Turmeric and ginger, many villages still struggle with technical knowledge and land optimization. Villages like Gaindikhata and Heerahedi show strong MAPs area utilization, but others like Hadipur Grant and Bahadurpur underperform despite large landholdings-showing that potential exists but is underutilized.

Tehri Garhwal lags significantly with the lowest adoption rate (16%). While diversity in crops is commendable-including unique species like Chamomile, Oregano and Black cumin, the cultivation remains small-scale. Challenges stem from difficult terrain, small fragmented holdings, lack of market access and poor awareness. Villages like Odarso and Haleth are bright spots, but most areas need focused support to scale MAPs cultivation.

**Key Challenges identified**

- Low awareness of MAPs market potential in remote villages (especially in Tehri).
- Fragmented landholdings and poor infrastructure hinder large-scale adoption.
- Limited access to subsidies, certification and training (less than 30% of farmers availed of these).
- Price volatility and middlemen dependency reduce farmer confidence in MAPs.
- Lack of organized marketing systems (e.g., missing auction platforms, grading).

**Opportunities**

- Leverage Dehradun's institutional base for region-wide capacity building.
- Utilize Haridwar's industrial base for processing and value-addition units in rural areas.
- Promote community-led MAP clusters and Farmer Producer Organizations (FPOs) in Tehri to scale adoption.
- Expand niche and high-value crops (e.g., Damask Rose, Stevia, Chamomile) in suitable microclimates.
- Integrate MAPs into organic and wellness tourism models across all districts.

## Conclusion

The study highlights that while Uttarakhand possesses the immense ecological and institutional capacity for the promotion of MAPs substantial inter-district disparities remain a critical barrier to uniform growth. Dehradun leads in adoption, owing to institutional proximity and awareness; Haridwar excels in land utilization and profitability due to industrial linkages; whereas Tehri Garhwal, despite its agro-diversity, continues to underperform due to infrastructural and informational limitations.

The economic analyses reaffirm that MAPs such as turmeric, ginger and aloe vera offer significant profitability when backed by adequate support systems. Yet, key constraints including low awareness, unorganized markets, price volatility and weak post-harvest infrastructure continue to limit the potential gains from MAP-based agriculture. Furthermore, limited access to certification, training and digital platforms inhibits broader farmer participation in high—value markets.

To bridge these gaps, a multi-pronged strategy is essential. Strengthening institutional outreach, expanding training and extension programs and incentivising MAP clusters through Farmer Producer Organisations (FPOs) can enhance adoption. Value chain integration through better post-harvest facilities, e-market linkages and branding can improve both profitability and sustainability. Finally, aligning MAPs cultivation with wellness tourism, organic farming and rural entrepreneurship presents a holistic model from long-term economic transformations.

In conclusion, the successful scaling of MAPs cultivation in Uttarakhand demands coordinated efforts from farmer policymakers, researchers and industry stakeholders. With region-specific strategies and ecosystem-sensitive planning, MAPs-based agriculture can serve as a cornerstone for rural resilience and sustainable development in the Himalayas.

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