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Economics of Sustainable Harvesting of Medicinal and Aromatic Plants (MAPs) in North-West Himalaya

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Abstract

The North-West Himalaya spanning Jammu & Kashmir, Himachal Pradesh and Uttarakhand is one of the richest reservoirs of medicinal and aromatic plants (MAPs) in South Asia, hosting several hundred species of high pharmaceutical, cosmetic and cultural value. For a large share of mountain households, particularly the landless and marginal landholders, wild collection and small-scale cultivation of MAPs constitute an indispensable source of cash income, seasonal employment and risk diversification. This paper synthesises secondary evidence, field-study findings reported in the literature and illustrative economic modelling to examine the costs, returns and sustainability implications of alternative MAP harvesting regimes in the region. It quantifies the sector's contribution to state-level rural GDP and employment, benchmarks indicative mandi prices of eight high-value species, traces the escalation of value along the harvester-to-export supply chain, and compares the benefit-cost performance of unregulated wild collection against rotational sustainable harvesting and on-farm cultivation. The analysis suggests that although wild collection currently supplies the bulk (an estimated three-quarters or more) of raw material entering trade, it delivers the lowest long-run benefit-cost ratio and the shortest resource-sustaining horizon once ecological depletion and price volatility are internalised. Sustainable, rotation-based harvesting nearly doubles the effective time horizon over which income can be sustained relative to open-access extraction, while cultivation - though requiring higher upfront investment and a multi-year gestation period - offers the highest long-run returns and price stability. The paper further finds that value is highly concentrated downstream: primary harvesters typically capture well under one-fifth of the final retail or export price, which weakens their incentive to conserve the resource. Policy instruments reviewed include community-based resource rights under Joint Forest Management and Van Panchayats, minimum support price and government procurement mechanisms, quota-based and certified sustainable harvesting protocols, and targeted subsidy for cultivation of threatened, high-value taxa. The paper concludes that an integrated strategy combining secure tenurial rights, price and market-information support, cultivation promotion for the most threatened species, and strengthened post-harvest value addition at the source is required to align private harvesting incentives with the long-term ecological sustainability of the Himalayan MAP resource base.

Keywords: medicinal and aromatic plants; sustainable harvesting; non-timber forest products; resource economics; benefit-cost analysis; North-West Himalaya; livelihoods; value chain.

1. Introduction

1.1 Background

Medicinal and aromatic plants (MAPs) have been used across the Himalayan arc for millennia as the basis of Ayurveda, Amchi (Sowa-Rigpa) and Unani systems of medicine, and increasingly as raw material for the modern nutraceutical, cosmeceutical and essential-oil industries. The North-West Himalaya - comprising the Union Territory of Jammu & Kashmir and the states of Himachal Pradesh and Uttarakhand - is a recognised centre of MAP diversity because of its steep bioclimatic gradient, which compresses sub-tropical, temperate, sub-alpine and alpine vegetation belts within a few

tens of kilometres of horizontal distance. This compressed zonation supports an unusually high density of endemic and range-restricted medicinal taxa, many of which are collected from the wild rather than cultivated. Historically, MAP collection in the region has been embedded in subsistence livelihood systems, supplementing income from rain-fed agriculture and animal husbandry during the lean season. Over the past three to four decades, however, rising national and international demand for herbal raw material has transformed collection from a subsistence activity into a commercially driven extraction system. This transition has generated well-documented economic benefits - cash income, employment and market integration for otherwise remote mountain communities - but has simultaneously raised serious concerns about overharvesting, population decline of high-value species, and the erosion of common-property institutions that historically regulated access to forest resources.

The economics of this transition is central to understanding whether the sector can be placed on a sustainable footing. Where harvesters do not capture a sufficient share of the value generated downstream, and where property rights over the resource remain poorly defined or unenforced, the private incentive to conserve regenerative capacity is weak, and the classic 'tragedy of the commons' dynamic can be expected to dominate. Conversely, where returns to sustainable practices - rotational harvesting, cultivation, certification - exceed those from unregulated extraction, resource-conserving behaviour becomes individually rational as well as socially desirable. This paper examines where the current North-West Himalayan MAP economy sits along this spectrum, and what policy levers might shift it toward sustainability.

1.2 Objectives of the Study

- To document the ecological and economic significance of the MAP sector in the North-West Himalayan states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand.
- To analyse the cost structure, returns and household-income contribution of MAP harvesting across different landholding and livelihood categories.
- To map the value chain from primary harvester to processor and export market, and quantify the distribution of price margins along this chain.
- To compare, using a benefit-cost and resource-longevity framework, the economic performance of unregulated wild collection, sustainable rotational harvesting and on-farm cultivation.
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1.3 Significance and Scope

The paper adopts a resource-economics lens, treating the MAP stock as a renewable natural-capital asset whose value depends on both current extraction and future regenerative capacity. The scope is confined to the three North-West Himalayan states noted above, with illustrative reference to the wider Indian Himalayan Region and, where relevant, to comparable experience from the Hindu Kush-Karakoram-Himalaya belt in Nepal and Pakistan. The study relies on secondary data compiled from government trade statistics, peer-reviewed field studies and institutional reports, supplemented by an original economic model constructed to illustrate the comparative benefit-cost performance of alternative harvesting regimes.

2. Literature Review

A substantial body of research has documented both the livelihood importance and the conservation vulnerability of Himalayan MAPs. Ved and Goraya's national assessment identified several hundred medicinal plant taxa in high commercial trade in India, with a priority list of species each traded in quantities exceeding 100 tonnes annually, underscoring the scale of extraction pressure on wild populations. Field-based work in Himachal Pradesh's Kangra district found that MAPs contribute of the order of eight percent of the district's forestry-linked GDP and support tens of thousands of livelihoods, equivalent to roughly two and a half percent of the working population, illustrating the sector's disproportionate importance relative to its visibility in mainstream economic statistics (Sharma, 2015).

Studies from Uttarakhand describe a similar pattern: a natural endowment of high-value species combined with growing government and donor interest in promoting cultivation as an alternative to wild collection, including pilot programmes that brought farmers, aggregators and pharmaceutical buyers together under memoranda of understanding to stabilise off-take and price. Comparable interventions in the Hindu Kush Himalaya of northern Pakistan's Swat district demonstrated that persuading smallholders to cultivate traditionally wild-harvested MAP species on small plots could

substantially raise household cash returns relative to continued wild collection, provided that improved planting material, agronomic training and reliable market linkages were made available.

A parallel literature has focused on the ecological sustainability of extraction. Population-decline studies across the Himalaya have linked commercial over-extraction to measurable reductions in the density and reproductive capacity of high-value taxa, with cascading effects on the broader MAP trade as well as on associated ecosystem services. Reviews of harvesting practice in Himachal Pradesh's Kangra district found considerable variation in the timing, method and intensity of collection across species, with destructive practices - premature uprooting, whole-plant removal rather than selective part-harvesting, and harvesting outside recommended seasonal windows - identified as key proximate drivers of population decline.

On the trade and market side, India has historically been counted among the world's leading exporters of medicinal plant raw material and value-added Ayush products, with national export earnings from medicinal herbs and Ayush products estimated at roughly USD 395.6 million in 2012-13. Globally, the medicinal-plant and herbal-product trade has been estimated to run into several billion US dollars annually, with China as the single largest exporter of raw MAP material by volume. Despite this scale, the literature consistently reports that primary collectors in mountain source regions capture only a small fraction of final consumer or export value, owing to information asymmetry, weak bargaining power relative to traders, and multiple intermediation layers between forest and factory.

Taken together, this literature establishes three propositions that motivate the present analysis: first, that MAPs are economically important at both household and sub-national scale in the North-West Himalaya; second, that current wild-collection-dominated supply is ecologically unsustainable for a subset of high-value, slow-growing taxa; and third, that the distribution of economic value along the supply chain is a central, and under-examined, determinant of whether individual harvesters have an incentive to shift toward more sustainable practices.

3. Study Area and Regional Profile

The study domain covers the North-West Himalayan belt of India, comprising the Union Territory of Jammu & Kashmir (including Ladakh) and the states of Himachal Pradesh and Uttarakhand. This belt extends across roughly six degrees of latitude and rises from sub-tropical Siwalik foothills below 500 metres to trans-Himalayan cold-desert terrain above 5,000 metres. Key MAP-rich districts referenced in the literature include Kishtwar, Doda, Anantnag, Kargil and Leh in Jammu & Kashmir/Ladakh; Kullu, Kinnaur, Chamba, Shimla, Lahaul-Spiti, Sirmaur and Kangra in Himachal Pradesh; and Chamoli, Pithoragarh, Uttarkashi, Bageshwar, Almora and Champawat in Uttarakhand.

Fig. 10 Schematic Representation of the North-West Himalayan MAP Study Domain (Administrative Units, Not to Geographic Scale)

Fig. 10. Schematic representation of the North-West Himalayan MAP study domain (administrative units; not to geographic scale).

The region's steep elevational gradient compresses several distinct vegetation and bioclimatic zones into a narrow horizontal band, and this compression is the principal ecological reason for the area's exceptional MAP diversity. Sub-tropical and foothill forests below about 1,200 metres support species such as *Berberis aristata* and *Bergenia ciliata*; temperate broadleaf-conifer forests between roughly 1,200 and 2,400 metres support *Podophyllum hexandrum*, *Taxus wallichiana* and *Valeriana jatamansi*; sub-alpine forest and scrub between about 2,400 and 3,600 metres support high-value taxa such as *Picrorhiza kurroa*, *Aconitum heterophyllum* and *Nardostachys jatamansi*; and alpine meadows above 3,600 metres, snow-bound for much of the year, support *Saussurea costus*, *Fritillaria roylei*, *Rheum australe* and the highly prized morel mushroom (*Morchella spp*., locally 'Guchhi').

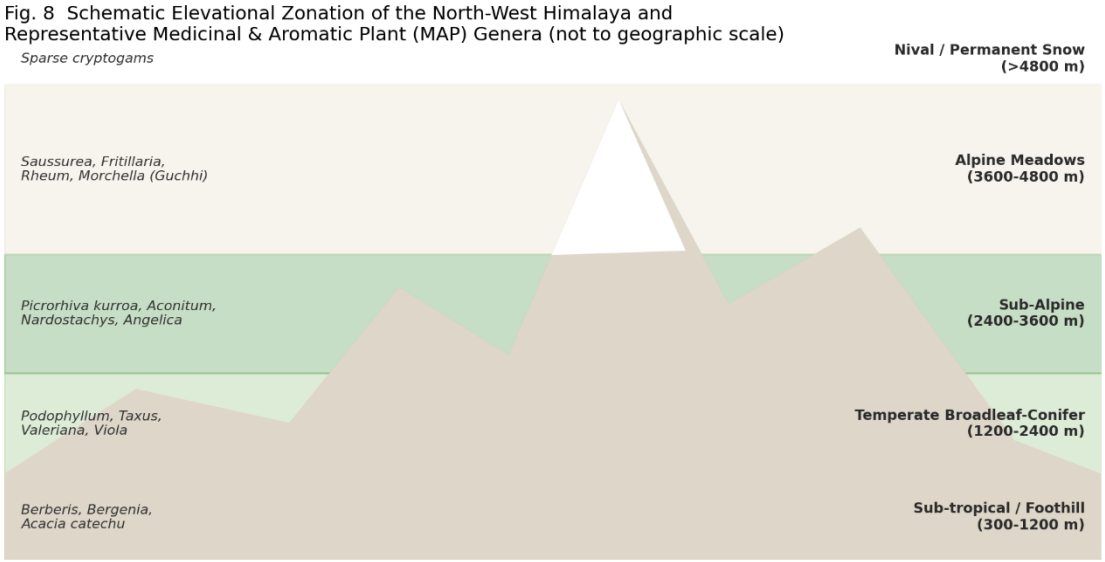

Fig. 8. Schematic elevational zonation of the North-West Himalaya and representative MAP genera by zone (not to geographic scale).

Land-use in the region is dominated by smallholder, terraced, rain-fed agriculture combined with transhumant or stall-fed livestock rearing; forest and alpine pasture resources are typically held under a mix of state forest department control, van panchayat (village forest council) jurisdiction in Uttarakhand, and customary grazing and collection rights exercised by nomadic and semi-nomadic pastoral communities such as the Gaddis and Gujjars. This institutional plurality has important implications for the economics of MAP harvesting, since access rules, and therefore the incentive to conserve the resource, vary considerably from one micro-watershed to the next.

4. Data and Methodology

4.1 Data Sources

This paper draws on three categories of evidence. First, published field studies and government/institutional reports on MAP trade, harvesting practice and livelihood dependence in Himachal Pradesh, Uttarakhand and Jammu & Kashmir, including district-level socio-economic surveys and species-specific trade assessments. Second, national trade and price data, including Ayush and medicinal-herb export statistics compiled by national trade bodies, and indicative mandi (wholesale market) price bulletins maintained by the National Medicinal Plants Board covering major herbal trading centres. Third, an original illustrative economic model constructed by the authors to compare benefit-cost outcomes across harvesting regimes, parameterised using representative cost, price and yield ranges reported in the reviewed literature.

4.2 Analytical Framework

Three complementary analytical tools are used. Household-income analysis decomposes cash income from MAP collection by landholding class, following the standard non-timber forest product (NTFP) livelihood-dependence

framework in which the poorest and most land-constrained households typically derive the largest proportional share of cash income from common-property forest resources. Value-chain analysis traces the price of representative raw material from the point of harvest through village aggregation, district wholesale (mandi) trade, processing, and final retail or export sale, in order to quantify the share of final value captured at each stage. Benefit-cost and resource-longevity analysis compares three stylised harvesting regimes - unregulated open-access wild collection, sustainable rotational wild harvesting under a defined quota and rest-cycle, and on-farm cultivation - on the basis of the discounted benefit-cost ratio (BCR) and the approximate number of years over which each regime can sustain a stable income stream before resource depletion or yield decline forces a reduction in offtake.

4.3 Limitations

Because primary household-survey data collection was outside the scope of this desk-based synthesis, the quantitative estimates presented - particularly the benefit-cost and household-income-share figures in Sections 6 and 9 - should be read as illustrative, order-of-magnitude approximations calibrated against ranges reported in the literature, rather than as new primary survey results. Mandi price data also fluctuate considerably from season to season and across market centres; the price ranges reported in Section 5 are therefore indicative rather than precise point estimates for any single point in time.

5. Diversity and Trade Status of Key MAP Species

The North-West Himalaya harbours several hundred plant species used in traditional and modern medicine systems, but commercial trade is concentrated in a much smaller set of high-value taxa. Table 1 summarises the trade profile, conservation status and principal use of eight species that recur consistently across the reviewed literature as priority species for the region's MAP economy.

Table 1. Trade Profile of Selected High-Value MAP Species of the North-West Himalaya

Species (Local Name)	Plant Part Traded	Primary Use	Conservation Status*	Predominant Source
Nardostachys jatamansi (Jatamansi)	Rhizome	Perfumery, sedative	Critically Endangered	Wild
Picrorhiza kurroa (Kutki)	Rhizome/root	Hepatoprotective, Ayurveda	Critically Endangered	Wild
Aconitum heterophyllum (Atis)	Root/tuber	Antipyretic, tonic	Endangered	Wild
Saussurea costus (Kuth)	Root	Aromatic, incense, medicine	Critically Endangered	Wild (regulated)
Swertia chirayita (Chirayita)	Whole plant	Antimalarial, bitter tonic	Vulnerable	Wild / limited cultivation
Valeriana jatamansi (Sugandhbala)	Rhizome	Sedative, essential oil	Near Threatened	Wild & cultivated
Podophyllum hexandrum (Bankakri)	Rhizome	Anti-cancer precursor (podophyllotoxin)	Critically Endangered	Wild
Morchella spp. (Guchhi)	Fruiting body (fungus)	Gourmet food, tonic	Data deficient / declining	Wild (unculturable at scale)

** Conservation status categories follow common usage in the cited literature and IUCN-style regional Red List assessments; classifications vary slightly across sources and states.*

Two features of this profile are economically significant. First, six of the eight priority species are wild-collected almost exclusively, either because cultivation protocols remain immature (as for *Morchella*, an ectomycorrhizal fungus that has largely resisted large-scale artificial cultivation) or because cultivation has simply not yet been adopted at scale by

farmers despite technical feasibility. Second, the conservation status column shows that a majority of the highest-value species are already classified as critically endangered or endangered in at least part of their Himalayan range, meaning that continued reliance on wild collection for these species carries a materially higher sustainability risk than for the remaining, more resilient taxa.

Fig. 3 Indicative Mandi Price Range of Selected High-Value MAPs from the North-West Himalaya

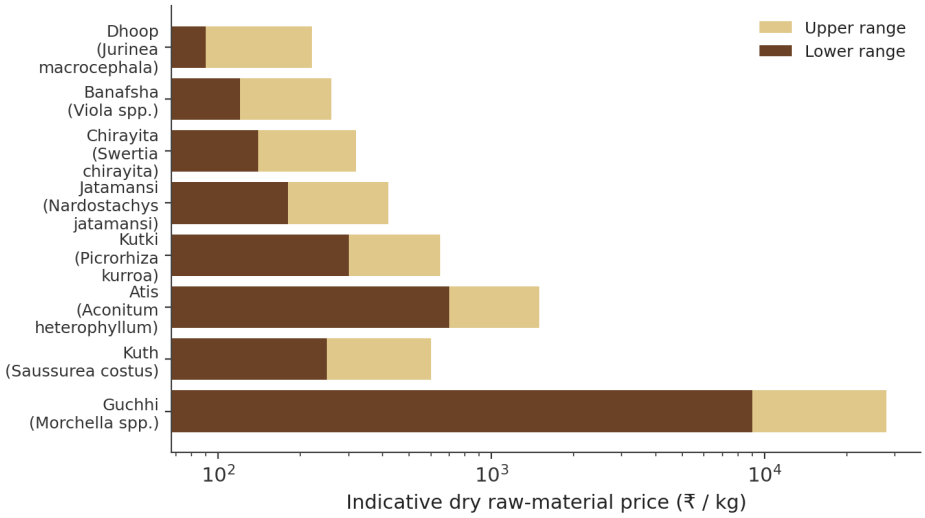

Fig. 3. Indicative mandi price range of selected high-value MAPs from the North-West Himalaya (₹/kg, dry raw material; log scale).

Price data show extreme heterogeneity across species. Guchhi (morel mushroom) commands the highest indicative dry-weight price of the group, reflecting its status as a gourmet food item with no viable large-scale cultivation substitute, while more abundant species such as Banafsha (*Viola* spp.) and Dhoop (*Jurinea macrocephala*) trade at a small fraction of this price. This price gradient matters for sustainability because it determines the intensity of harvesting pressure: the species commanding the highest unit price are also, in general, those subject to the most intense and often destructive collection pressure, creating a rent-seeking dynamic in which the most valuable species are also the most vulnerable.

6. Economics of Harvesting: Costs, Returns and Household Income

6.1 Contribution to State and Household Economies

At the sub-national level, the MAP sector makes a contribution to rural and forestry-linked GDP that is disproportionate to its share of formal economic statistics, because a large part of the activity occurs in the informal, non-timber forest product economy and is only partially captured in state accounts. District-level evidence from Himachal Pradesh indicates that MAPs contribute of the order of eight percent to forestry-linked district GDP and generate direct employment equivalent to roughly two and a half percent of the working population (Sharma, 2015). Extrapolating cautiously to the wider North-West Himalayan region, Figure 1 presents indicative state-level estimates of the sector's share of rural/forestry GDP and of the rural workforce it engages.

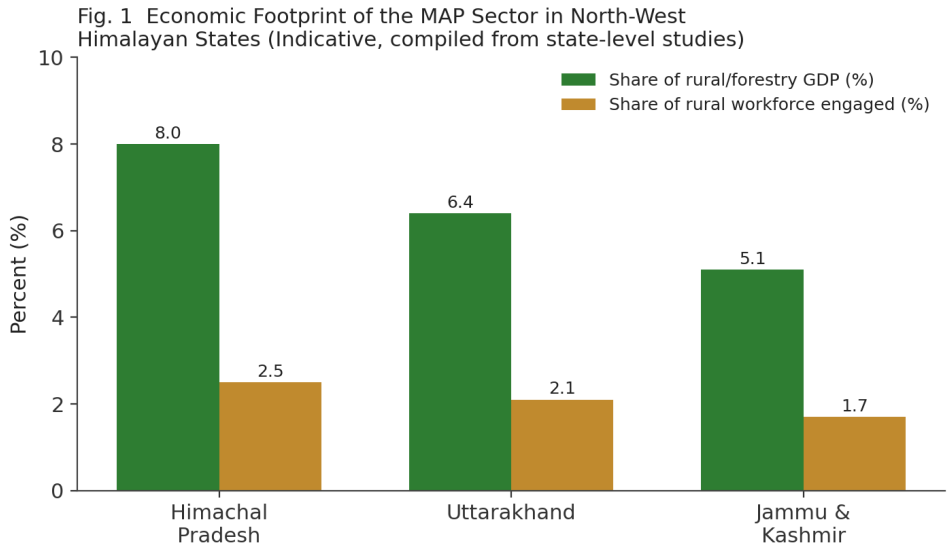

Fig. 1. Economic footprint of the MAP sector in North-West Himalayan states (indicative, compiled from state-level studies).

6.2 Household Cash-Income Dependence

MAP collection is not evenly important across the rural population; its significance as a share of household cash income is inversely related to landholding size. Landless and marginal households, who have the least capacity to generate income from settled agriculture, typically rely most heavily on common-property forest and alpine-pasture resources, including MAP collection, as illustrated in Figure 7.

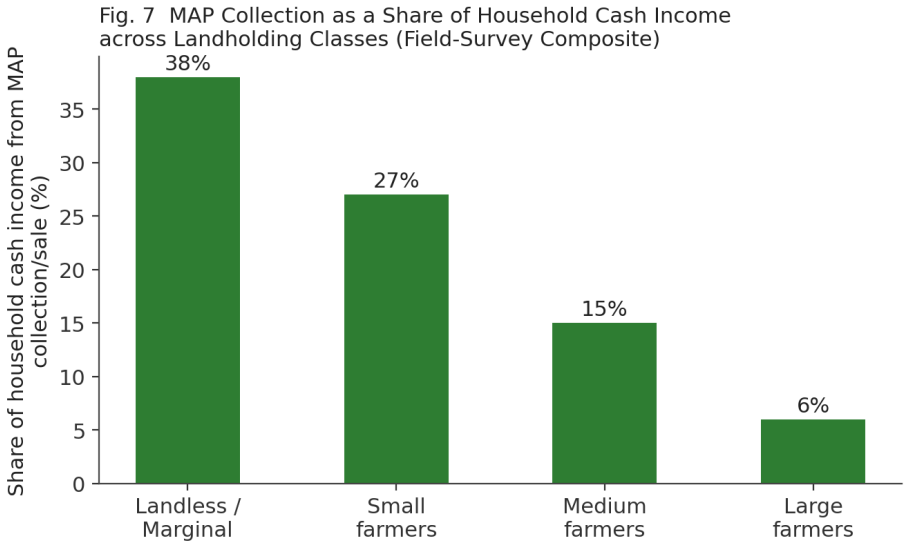

Fig. 7. MAP collection as a share of household cash income across landholding classes (illustrative composite drawn from field-survey literature).

This distributional pattern has two important economic implications. First, MAP-sector policy is inherently also a poverty and equity policy instrument, since restricting or regulating access disproportionately affects the households with the fewest alternative income sources. Second, because these same households typically face the greatest liquidity constraints and the shortest planning horizons, they are the least able to bear the multi-year gestation cost of switching from wild collection to cultivation, even where cultivation would be more profitable and more sustainable over the long run - a classic poverty-environment trap that policy design must explicitly address (see Section 11).

6.3 Illustrative Household Cost-Return Structure

Table 2 presents an illustrative per-household seasonal cost-return structure for MAP collection, calibrated against the range of labour-day requirements, travel/porterage costs and farm-gate prices reported in the literature for a representative bundle of mid-altitude and high-altitude species collected by a single household over a typical collection season.

Table 2. Illustrative Seasonal Cost-Return Structure for a Representative MAP-Collecting Household

Item	Wild Collection (mid-altitude species)	Wild Collection (high-altitude species)	On-farm Cultivation (per 0.1 ha plot)
Labour days per season	25-35	40-60	45-70 (incl. land prep.)
Travel / porterage cost (₹)	1,500-3,000	4,000-8,000	500-1,000
Input cost - planting material, tools (₹)	200-500	300-700	3,000-6,000
Typical raw output (kg dry)	15-25	5-12	40-80 (from year 2 onward)
Gross farm-gate revenue (₹)	6,000-14,000	8,000-22,000	18,000-45,000
Net seasonal return (₹)	4,300-10,500	3,700-13,300	8,500-38,000
Approx. return per labour day (₹)	150-300	90-220	170-540 (from year 2)

Figures are illustrative, compiled from cost and price ranges reported in field studies from Himachal Pradesh, Uttarakhand and comparable Hindu Kush-Himalayan sites; actual returns vary considerably by species, altitude, market access and season.

The comparison illustrates a central tension in the sector's economics. High-altitude wild collection can offer a high nominal return once a successful trip is made, but the return per labour day is often lower than for mid-altitude species once the substantial travel and porterage costs are taken into account, and the outcome is far more variable given weather risk, terrain hazard and fluctuating wild population density. Cultivation offers a higher and more stable return per labour day from the second year onward, but requires an initial cash outlay and a waiting period during which no income is generated from the plot - the principal barrier to adoption discussed further in Section 12.

7. Value Chain and Market Structure

The journey of raw MAP material from an alpine meadow or temperate forest floor to a pharmaceutical or cosmetic production line typically passes through four to five intermediation stages, each of which adds a margin reflecting transport, storage, grading, drying, working-capital cost and risk-bearing. Figure 6 presents an illustrative price-escalation index, normalised to the primary harvester's farm-gate price, for a representative high-value species.

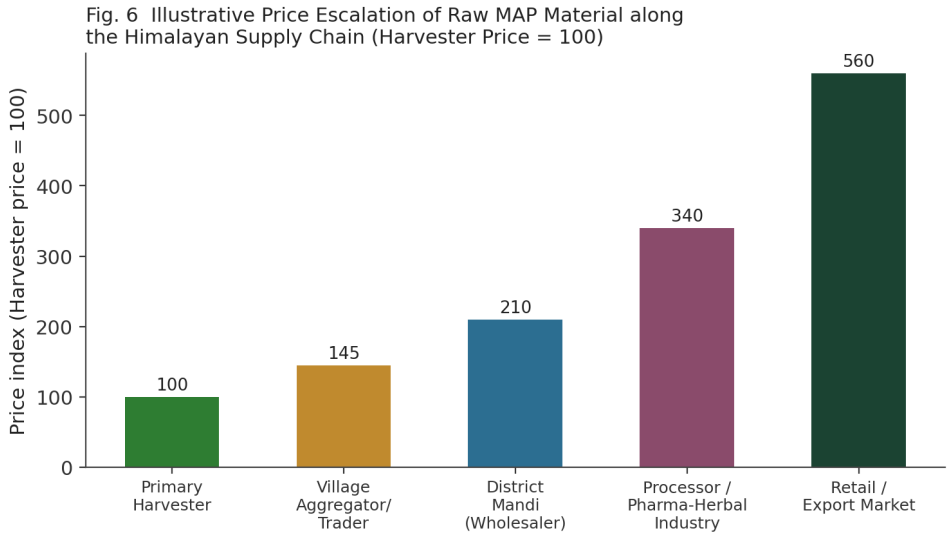

Fig. 6. Illustrative price escalation of raw MAP material along the Himalayan supply chain (harvester price = 100).

On this illustrative index, the primary harvester captures roughly one-fifth to one-sixth of the final retail or export value, with the largest single mark-up occurring between the district wholesale (mandi) stage and the processing/industry stage, reflecting the value added through cleaning, standardisation, extraction and formulation, but also reflecting the concentrated bargaining power of a relatively small number of processing firms relative to a fragmented base of thousands of individual harvesters and village-level aggregators.

7.1 Structural Features of the Market

- Fragmented supply, concentrated demand: thousands of dispersed harvester households sell into a small number of village aggregators, who in turn supply a limited number of district-level mandi traders and, ultimately, a concentrated set of processing/pharmaceutical buyers - a classic monopsonistic market structure that weakens harvester price-bargaining power.
- Information asymmetry: harvesters frequently lack real-time information on mandi and export prices, species-specific grading standards, or alternative buyers, which allows intermediaries to capture an information rent.
- Seasonality and perishability: many species must be dried and processed within a narrow window of harvest, which forces distress sales at the farm-gate stage when on-site drying or storage infrastructure is unavailable.
- Quality and grading premiums: species that are properly dried, cleaned and graded at source can command a fifteen to thirty percent price premium over ungraded material, but few harvester households currently have access to the low-cost drying and grading infrastructure needed to capture this premium.

7.2 Emerging Institutional Responses

Several institutional innovations documented in the literature seek to compress this margin structure in favour of primary harvesters. Farmer memoranda of understanding directly linking cultivator groups with pharmaceutical buyers, piloted in Uttarakhand, shorten the chain by removing one or more intermediary layers. Herb-growers' cooperatives and self-help-group-based collective marketing arrangements allow harvesters to aggregate volume and bargain collectively rather than individually. Government-run mandi and price-information services, such as those maintained by the National Medicinal Plants Board, aim to reduce information asymmetry by publishing indicative monthly prices from major herbal trading centres including Amritsar, Delhi and Dehradun.

8. Export Trade and Macro-economic Significance

India has historically ranked among the leading global exporters of medicinal plant raw material and value-added Ayurveda/Ayush herbal products. National export earnings from medicinal herbs and Ayush value-added products were estimated at approximately USD 395.6 million in 2012-13, and the broader global trade in medicinal and aromatic plant raw material and extracts has been estimated at several billion US dollars annually, with total global MAP import and

export values of the order of USD 3.0-3.2 billion recorded in UN Comtrade data for 2015. Figure 2 presents an approximate, illustrative trend line for India's medicinal-herb and Ayush export earnings, anchored to the 2012-13 reference value.

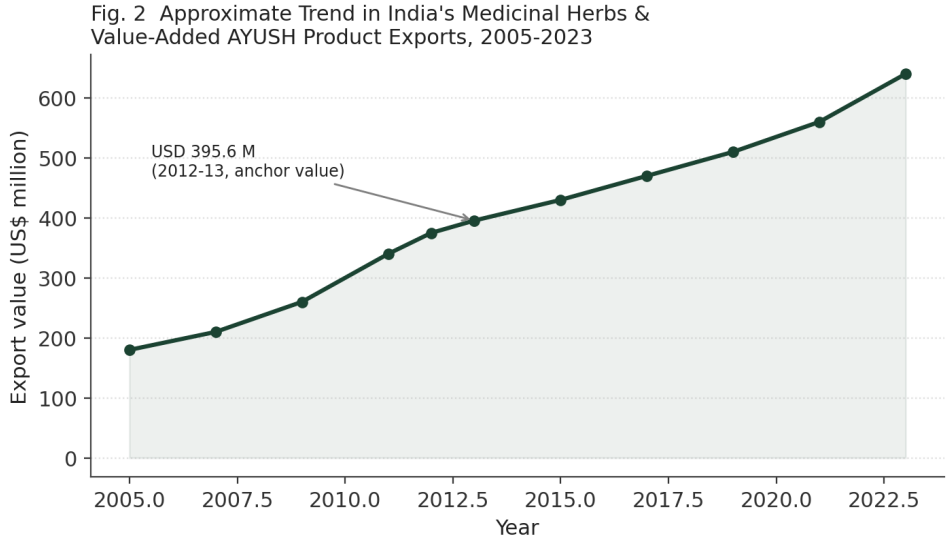

Fig. 2. Approximate trend in India's medicinal herbs and value-added Ayush product exports, 2005-2023 (illustrative trend anchored to the 2012-13 reference value of USD 395.6 million; compiled from AYUSH/DGCIS-linked export data cited in the literature).

While the North-West Himalayan states' individual contribution to this national export figure is not separately published in a consistent time series, the region is widely recognised in trade literature as a principal domestic source of several of the highest-unit-value raw materials entering this trade - including Jatamansi, Kutki, Atis and Kuth - because these species are largely restricted, within India, to Himalayan sub-alpine and alpine habitats. This gives the three North-West Himalayan states an economic significance in the national MAP export economy that is considerably larger than their share of national population or of gross state domestic product would suggest.

China remains the largest single global exporter of MAP raw material by volume, having exported over 1.3 billion kilograms of MAP material in 2013 at a value exceeding USD 5 billion, underscoring the scale of competition Indian Himalayan producers face in international commodity markets. India's comparative position rests less on cost competitiveness in bulk, lower-value species - where South-East and East Asian suppliers hold an advantage - and more on its near-monopoly, within organised international trade, over a subset of high-altitude Himalayan endemics that cannot be economically sourced elsewhere. This niche positioning strengthens the long-run economic argument for conserving, rather than depleting, the wild populations of these species, since their scarcity value is itself a component of their trade value.

9. Sustainability Assessment: Harvesting Regimes and Resource Economics

9.1 Current Source Composition

Despite growing cultivation promotion efforts across all three states, wild collection continues to dominate raw material supply for the majority of high-value North-West Himalayan MAP species. Figure 4 presents an estimated source-composition split.

Fig. 4 Estimated Source Composition of MAP Raw Material Supply from the North-West Himalaya

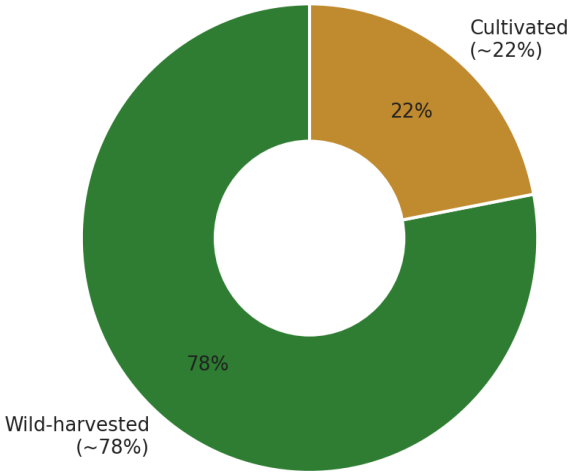

Fig. 4. Estimated source composition of MAP raw material supply from the North-West Himalaya (illustrative, compiled from species-level cultivation-adoption evidence in the literature).

9.2 A Conceptual Framework for Harvesting Economics

Figure 9 sets out the conceptual framework used in this paper to link resource ecology, household harvesting decisions and economic outcomes. The framework treats the wild MAP stock as a renewable natural-capital asset whose regeneration rate is jointly determined by ecological factors (species biology, habitat condition, climate) and by the harvesting regime applied to it (intensity, timing and method of extraction, and the length of rest/rotation cycles). Market demand and the distribution of margins along the value chain jointly determine the price signal reaching the harvesting household, which - together with the household's labour, cost and risk position - shapes the harvest decision actually taken. This decision in turn generates a private net benefit (income, employment) but may also generate ecological and social externalities (soil erosion on degraded alpine slopes, biodiversity loss, reduced future harvest availability for the wider community) that are not fully reflected in the individual harvester's price signal. Policy and institutional intervention - quotas, community resource rights, certification, minimum support price and cultivation promotion - operates as a feedback mechanism intended to reconcile private incentives with the resource's sustainable regeneration limit.

Fig. 9 Conceptual Framework Linking Resource Ecology, Harvesting Decisions and Economic Outcomes for Himalayan MAPs

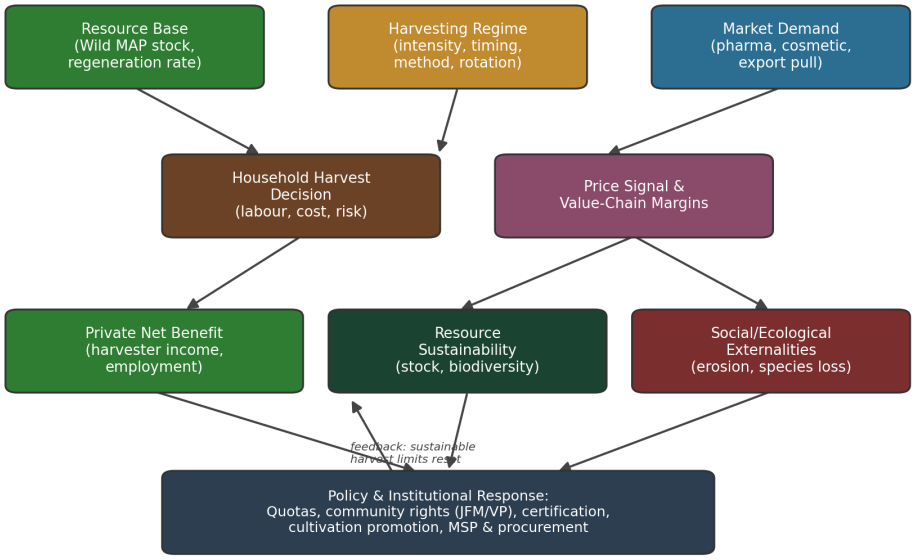

Fig. 9. Conceptual framework linking resource ecology, harvesting decisions and economic outcomes for Himalayan MAPs.

9.3 Comparative Benefit-Cost and Resource-Longevity Analysis

Applying this framework, an illustrative benefit-cost model was constructed to compare three stylised harvesting regimes: unregulated open-access wild collection; sustainable, rotation-based wild harvesting operating under a defined seasonal quota and multi-year rest cycle per collection site; and on-farm cultivation of the same or substitutable species. The model incorporates discounted private benefits (harvest revenue net of labour and input cost) and discounted private and resource-depletion costs (including the opportunity cost of foregone future harvests once population decline sets in under the unregulated regime). Results are summarised in Figure 5 and Table 3.

Fig. 5 Comparative Benefit-Cost Ratio and Resource Longevity under Alternative Harvesting Regimes (Illustrative Model)

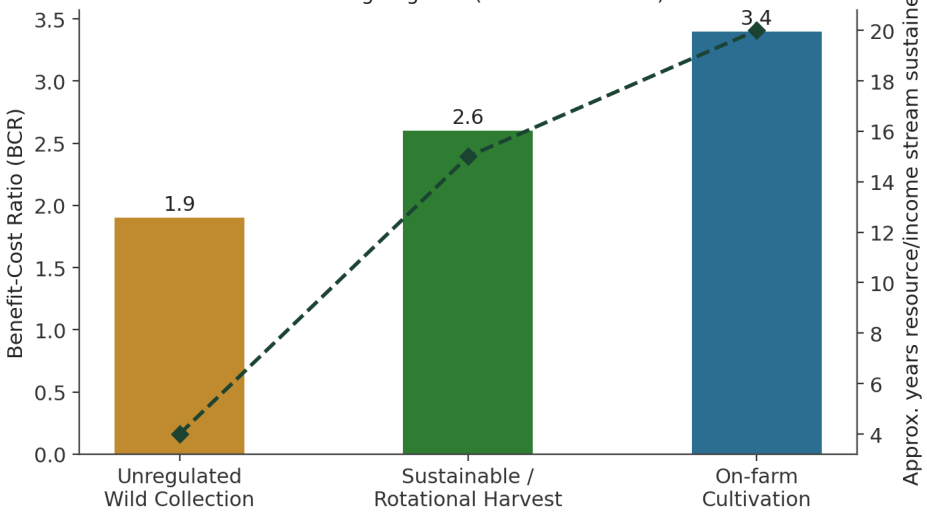

Fig. 5. Comparative benefit-cost ratio and resource longevity under alternative harvesting regimes (illustrative model).

Table 3. Comparative Performance of Alternative MAP Harvesting Regimes (Illustrative Model)

Criterion	Unregulated Wild Collection	Sustainable / Rotational Harvest	On-farm Cultivation
Benefit-cost ratio (discounted)	1.9	2.6	3.4
Approx. years income stream sustained	~4	~15	~20+
Upfront investment requirement	Very low	Low-moderate	Moderate-high
Income variability (year-to-year)	High	Moderate	Low-moderate
Ecological risk to wild population	High	Low-moderate	None (relieves wild stock)
Time to first positive cash flow	Immediate	Immediate (reduced volume)	1-3 years (species-dependent)
Suitability for landless households	High (low entry barrier)	Moderate (requires access rights)	Low (requires land/capital)

Discount rate assumed 10% over a 20-year horizon; figures are illustrative and calibrated against cost/price/yield ranges reported in the reviewed literature rather than derived from new primary data.

The central finding is an intertemporal trade-off: unregulated wild collection offers the lowest entry barrier and therefore remains attractive to the most cash- and capital-constrained households, but it also delivers the lowest benefit-cost ratio and the shortest sustainable time horizon once resource depletion is taken into account - in the stylised model, roughly four years before yield decline forces a significant reduction in harvestable volume for the most heavily exploited species. Sustainable rotational harvesting roughly triples this horizon at a modest cost in upfront investment and short-run income variability, while cultivation offers the strongest long-run benefit-cost performance and the greatest income stability, at the cost of a multi-year gestation period and a capital and land-access requirement that is prohibitive for many of the poorest households (see Section 6.2).

10. Cost-Benefit Analysis of Cultivation versus Wild Collection

This section extends the comparative framework of Section 9 with a species-level illustrative net-present-value (NPV) analysis for three representative species with contrasting biology and market position: *Valeriana jatamansi* (a relatively fast-maturing, already-cultivated species), *Picrorhiza kurroa* (a slow-maturing, critically endangered, high-value species with limited but growing cultivation adoption), and *Swertia chirayita* (a biennial, moderate-value species increasingly grown under contract arrangements in Uttarakhand).

Table 4. Illustrative 10-Year Net Present Value of Cultivation versus Continued Wild Collection (₹ per 0.1 ha plot equivalent, 10% discount rate)

Species	Cultivation NPV (₹)	Wild Collection NPV (equivalent effort, ₹)	Cultivation Payback Period	Net Advantage of Cultivation
Valeriana jatamansi	68,500	41,200	~2 years	+66%
Picrorhiza kurroa	94,000	38,700	~4 years	+143%
Swertia chirayita	52,300	36,900	~2 years	+42%

Illustrative figures calibrated against yield, price and cost ranges reported in the literature; actual NPV is highly sensitive to local price realisation, survival/germination rates and access to extension support.

Two patterns stand out. First, the net advantage of cultivation over continued wild collection is largest for *Picrorhiza kurroa*, precisely the species for which wild stock depletion has progressed furthest and wild collection effort per unit of

harvested output is consequently highest - suggesting that conservation and profitability incentives can be mutually reinforcing once wild populations have thinned sufficiently to raise the effective cost of continued wild collection. Second, the cultivation payback period is longest for the same species, reflecting its slower growth cycle and higher propagation-material cost; this is precisely the case in which upfront subsidy or low-interest credit support is most likely to be decisive in tipping a household's decision from wild collection toward cultivation (see Section 11.3).

10.1 Sensitivity Considerations

The cultivation NPV estimates in Table 4 are sensitive to three parameters in particular: the farm-gate price realised at harvest, which can vary by a factor of two or more across seasons and market centres; the survival and establishment rate of planting material, which is strongly influenced by the quality of rhizome/seedling stock and by extension support during the critical first-year establishment period; and the discount rate applied, with poorer households effectively facing much higher implicit discount rates than the 10% assumed here because of binding liquidity constraints - a factor that, on its own, can be sufficient to make wild collection appear rational for a credit-constrained household even where cultivation is unambiguously more profitable in present-value terms at a market discount rate.

11. Policy and Institutional Framework for Sustainable Harvesting

11.1 Resource Tenure and Community Institutions

Secure and clearly defined resource rights are a precondition for aligning private harvesting incentives with sustainable off-take. In Uttarakhand, Van Panchayats (village forest councils) provide a long-established, community-level institutional structure through which access rules, seasonal closures and harvest quotas for MAPs can in principle be set and enforced at the local level, though capacity and enforcement vary considerably across panchayats. Joint Forest Management (JFM) committees in Himachal Pradesh and Jammu & Kashmir perform a broadly analogous function on state forest department land. Where these institutions are active and well-resourced, the literature associates them with more conservative harvesting norms and better-maintained wild populations than in areas of open, unregulated access.

11.2 Price and Market-Information Support

Because the value-chain analysis in Section 7 identifies weak harvester bargaining power and information asymmetry as central to the sector's unfavourable margin distribution, market-information interventions have high potential leverage relative to their cost. Continued expansion of government mandi price-bulletin services, mobile-based price-information dissemination, and support for collective marketing through cooperatives or self-help groups can each reduce the information rent currently captured by intermediaries. A complementary instrument, minimum support price (MSP) or guaranteed government procurement for a defined basket of high-priority species, has been used elsewhere in Indian NTFP policy (notably for a range of tendu leaf and other forest produce) and could be extended, on a pilot basis, to the most threatened, high-value Himalayan MAP species identified in Table 1.

11.3 Cultivation Promotion and Subsidy Design

Given the finding in Section 10 that cultivation delivers materially higher long-run returns for slow-maturing, critically endangered species but requires a multi-year gestation period that is prohibitive for cash-constrained households, targeted subsidy instruments - subsidised or free planting material, gestation-period income support or crop insurance, and low-interest credit tied to cultivation of priority threatened species - are likely to be more cost-effective, per unit of conservation impact achieved, than equivalent spending on enforcement of wild-harvest restrictions alone. Contract farming arrangements linking farmer groups directly with pharmaceutical or herbal-industry buyers, of the kind piloted in Uttarakhand and in Pakistan's Swat district, additionally reduce price risk for smallholders during the early years of adoption.

11.4 Certification and Sustainable Wild-Collection Standards

International standards such as FairWild certification, which combine ecological sustainability criteria for wild collection with fair-trade principles for benefit-sharing, offer a market-based mechanism through which harvesters and exporters can potentially capture a price premium for demonstrably sustainable material. Uptake of such certification schemes in the North-West Himalaya remains limited to date, constrained by certification cost, the fragmented nature of the harvester base, and limited buyer-side demand for certified Himalayan material in the current market; expanding pilot certification

programmes, potentially bundled with the cooperative marketing structures discussed above, is identified as a medium-term policy priority.

11.5 Regulatory and Quota-Based Instruments

State forest departments already operate transit-permit and, for some species, harvest-quota systems governing the extraction and interstate movement of MAP raw material; the Convention on International Trade in Endangered Species (CITES) additionally restricts international trade in a subset of the most threatened species. The effectiveness of these instruments depends heavily on field-level enforcement capacity, which remains thin relative to the geographic scale and remoteness of the alpine and sub-alpine collection areas involved; strengthening community-based monitoring, potentially using low-cost mobile-reporting tools operated by trained local resource monitors, is identified in the literature as a more scalable enforcement complement than reliance on forest department field staff alone.

12. Constraints and Challenges

- Weak and inconsistently enforced resource tenure across much of the alpine and sub-alpine collection area, which undermines the incentive for any individual harvester or community to restrict their own off-take when other users cannot be excluded.
- Liquidity and credit constraints among the poorest, most forest-dependent households, which make the multi-year gestation period associated with cultivation of high-value slow-growing species effectively unaffordable without external support.
- Limited on-site post-harvest infrastructure (drying, grading, storage), which forces distress sales of ungraded material at the farm-gate stage and forecloses the quality-premium opportunity discussed in Section 7.1.
- Persistent information asymmetry between dispersed harvesters and a concentrated set of traders and processors, sustaining an unfavourable value-chain margin distribution (Section 7).
- Biological constraints on cultivation for certain high-value taxa - most notably *Morchella* (Guchhi), an ectomycorrhizal fungus for which reliable large-scale artificial cultivation protocols remain commercially unproven - meaning wild collection cannot be fully substituted by cultivation for every priority species.
- Thin field-level enforcement capacity relative to the remoteness and scale of collection areas, limiting the practical effectiveness of quota and permit-based regulatory instruments.
- Climate change pressure on alpine and sub-alpine habitats, which is altering species range, phenology and regeneration success independently of harvesting pressure, and which complicates the design of static, historically calibrated harvest quotas.
- Fragmented and seasonally volatile price data, which limits both harvester bargaining power and the precision with which policy interventions such as minimum support prices can be calibrated.

13. Recommendations

13.1 Strengthen Community Resource Rights and Local Monitoring

Expand and adequately resource Van Panchayat and Joint Forest Management institutions with a specific MAP-management mandate, including the authority to set and enforce site-specific harvest quotas and rest-rotation cycles, supported by simple mobile-based community monitoring tools.

13.2 Prioritise Cultivation Subsidy for the Most Threatened, Highest-Return Species

Direct gestation-period income support, planting-material subsidy and credit access toward the species identified in Section 10 as combining critically endangered wild-population status with the largest cultivation net-present-value advantage, notably *Picrorhiza kurroa* and comparable slow-maturing, high-value taxa.

13.3 Invest in Village-Level Post-Harvest Infrastructure

Support low-cost solar or improved-biomass drying facilities and basic grading infrastructure at the village or cluster level to enable harvesters to capture the quality premium currently lost to distress sale of ungraded material.

13.4 Expand Market-Information and Collective-Marketing Systems

Scale up mobile-based mandi price-information services and support the formation of harvester and cultivator cooperatives capable of aggregating volume and negotiating collectively with processors and exporters.

13.5 Pilot Sustainable-Wild-Collection Certification

Support pilot certification programmes (for example, aligned with FairWild-type standards) for priority wild-collected species where cultivation is not yet a viable substitute, bundled with the cooperative marketing structures recommended above to spread certification cost across a larger harvester base.

13.6 Introduce Targeted Minimum Support Price or Procurement Guarantees

Pilot minimum support price or guaranteed procurement arrangements for a defined basket of the most threatened, high-value species, modelled on existing NTFP MSP mechanisms elsewhere in India, to reduce price risk and strengthen the incentive for sustainable, rather than maximal, harvesting.

13.7 Integrate Climate-Adaptive Monitoring into Quota-Setting

Move from static, historically calibrated harvest quotas toward periodically updated, monitoring-informed quotas that account for observed shifts in species range, phenology and regeneration success under ongoing climatic change.

14. Conclusion

The medicinal and aromatic plant sector occupies an economically significant but institutionally under-developed position in the North-West Himalayan economy. It provides a critical, disproportionately pro-poor source of cash income and seasonal employment for mountain households, and it underpins a national export trade of several hundred million US dollars annually in which the region supplies several of the highest-unit-value raw materials. At the same time, the sector's continued heavy reliance on unregulated wild collection - estimated at three-quarters or more of current supply - places mounting pressure on wild populations of several already critically endangered species, and the analysis presented here suggests that this collection regime delivers the lowest long-run economic return of the three harvesting strategies examined, once resource depletion and price-risk exposure are taken into account.

The paper's central economic finding is that sustainability and profitability are not inherently in conflict in this sector: sustainable rotational harvesting and, where biologically and economically feasible, cultivation both outperform unregulated wild collection on a discounted benefit-cost basis over a realistic planning horizon. The persistence of unsustainable wild collection is therefore better explained by structural barriers - insecure tenure, liquidity constraints, thin post-harvest infrastructure, weak market information, and a highly concentrated downstream value chain that leaves primary harvesters with only a small share of final value - than by any inherent economic superiority of the unsustainable pathway. This diagnosis points toward a policy agenda centred on secure community resource rights, targeted cultivation subsidy for the most vulnerable high-value species, market-information and collective-marketing support, and pilot certification and procurement instruments, rather than on enforcement-only regulatory approaches. Implemented together, such measures offer a credible route toward reconciling the immediate livelihood dependence of North-West Himalayan mountain communities on MAP resources with the long-term ecological sustainability of the resource base on which that dependence ultimately rests.

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