ORIGINAL ARTICLE

Ethno-pharmacological Interventions and Value Chain (VC) of Medicinal Plants (MPs): A Cohesive Approach for Sustained Livelihood

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Abstract

Introduction: It is imperative to ascertain and validate the importance of medicinal plants (MPs) as one of the significant pointers of socio-economic development. Value chains (VCs) and effective supply chain management system are essential tools for establishing a network of farm produce until it is end-use as a value-added processed product. This necessarily requires throughput policy initiatives for bridging raw produce until grass-root innovative practices are attained as value addition. This hierarchical platform in Indian context is being catered to by National MPs Board under Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy. Key step lies in connecting socio-ecological, ethnopharmacological, and socio-economic factors and deciphering all the probable pathways leading to revenue generation by involving all stakeholders in a VC. **Methods:** Through extensive literature search encompassing 90 articles and book chapters, 8 web links, 3 conference proceedings, and 5 reports released by the World Health Organization, USAID, and Food and Agriculture Organization respectively on VC analysis of MPs in Indian context, we prepared metadata. **Results:** This metadata comprehensively led to our understanding of identifiable gaps in ethnopharmacological studies and a need to re-route the VC involving institutional settings and NGOs in particular. This also led to our understanding of further exploratory studies aimed at the establishment of pharmacovigilance centers, DNA barcoding for unknown species, and best conservation practices. **Discussion:** Essentially, VCs act as a conglomerate of agriculture/horticulture, technical interventions leading to innovations, sustainable and viable business models with utmost profit to main stakeholder – The farmer. Need of an hour is to stringently monitor and establish an equilibrium between demand versus supply. This can be facilitated by a convergence of all stakeholders, including farmers, scientists, industrialists, innovators, policymakers, and traditional healers. **Conclusion:** Different policy initiatives have been envisaged and executed by Government support systems to establish a cohesive approach between producers and consumers with an impetus to innovative technology development followed by its transfer to industrial counterparts. This integrative concept would not only lead to value proposition in MPs sector but would also have a way for the establishment of special-purpose vehicles leading to financial sustenance hence promoting a probabilistic gateway to circular economy.

Key words: Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy, DNA barcoding, Ethno-pharmacology, Value chain, World Health Organization

INTRODUCTION

Medicinal plants (MPs) comprise botanical raw materials which have immensely contributed to robust healthcare practices and sustained livelihood.[1] Regardless, MPs have been categorized as one of the most valuable non-timber forest products.[2,3] The demand of MPs has witnessed a tremendous increase, they being considered as powerhouses for curing diseases in addition to their use as

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Received: 09-04-2021
Revised: 12-05-2021
Accepted: 19-05-2021

potential raw materials for use in the pharmaceuticals, cosmetics, and drug manufacturers, leading to a very high domestic and export potential.[4] Globally, next to China, Indian MPs have occupied a promising position for having possessed curative properties. Majorly, Indian states of Gujarat, Rajasthan, Haryana, Tamil Nadu, Andhra Pradesh, and Trans Himalayan Region constitute rich reserves of MPs. 90% of MPs are collected from wild, given the fact, 1000 species are under threat to loss.[5] A continuous increase in anthropogenic activities has led to exploitation, destruction, and loss to biodiversity. In addition, increased demand for natural products and global trade has contributed significantly to unprecedented losses.[6,7] Until recently, Convention on Biological Diversity and the Convention on International Trade in Endangered Species are stringently monitoring to trading of threatened species. Pharmacovigilance systems are being monitored by guidelines developed by World Health Organization (WHO) and international trade of cultivated plant products is being monitored by Food and Agriculture Organization.[8,9]

DNA Barcoding: Molecular Approach to Decipher Unknown Species

MPs undergoing trade remain unidentifiable identifiable to species level. As a general practice, they are characterized based on their morphological or pharmacological properties, given the fact as they may exist in dried, powdered, processed, or commercialized in a mixed formulation. Design, conservation, and implementation of conservation policies require the geographic origin of species in trade.[10] DNA barcoding has proven to be an effective tool in species-level identification in animals using a portion of the mitochondrial marker Cytochrome Oxidase 1 (COI). In plants, standard DNA barcoding involves using varying combinations of one to four plastid DNA regions (*rbcL, matK, trnH-psbA, trnL*) and/or the internal transcribed spacers of nuclear ribosomal DNA (nrDNA ITS). Although these markers have proved to be information yielding, no single marker or combination of these markers routinely provides complete species-level resolution, especially in species-rich groups.[11,12] High Throughput Sequencing utilizing advanced sequencing chemistries have resulted in DNA barcoding in plants.[13-15] Barcoding of loci has led to the inception of two major approaches for increasing the resolution (and coverage) of plant DNA barcoding [Figure 1].

Shallow pass shotgun sequencing (genome skimming) is now frequently used to recover organellar genomes and nuclear ribosomal DNA sequences, increasing the amount of data per sample, and leading to increased resolution.[16,17] Target capture sequencing efficiently targets hundreds of low-copy nuclear markers, which provides access to a much greater number of independent data points per unit of sequencing effort.[18] Both the techniques have successfully implemented sequencing of degraded DNA samples with an option of multiple samples being sequenced at a time with the possibility of recovery of standard DNA barcodes in the same assay.[19-22]

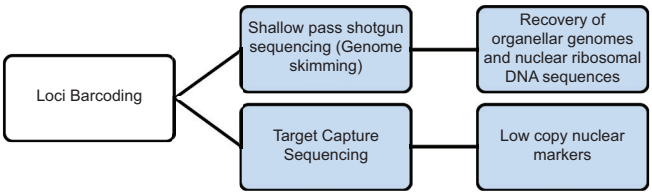

Figure 1: DNA barcoding

Asian Traditional Medicinal Practices

A lucid overview of traditional medicinal practices in Asia is represented in Figure 2.[23,24]

Traditional herbal medicines are inherent to indigenous knowledge systems. These rational systems play a crucial role in decision-making in terms of MPs being used by local communities.[25] For close to two centuries, MPs have been featured in modern drugs possessing active pharmaceutical ingredients of immense therapeutic value.[26-28] It is estimated that 70% of the population of developing nation relies on traditional medicine for primary health care needs[29,30] and so do the industrialized nations have an indirect dependence on MPs for their pharmaceutical products.[31,32] It is postulated that 25% of modern pharmacopeia and 18% of 150 prescription drugs owe their origin to MP derived constituents.[33,34] It has been speculated that Asian MPs accounts for about 50% of export leading to 45% of global earnings from traditional medicines.[35] Asian biodiversity reserves of MPs are known to house 38,600 species.[36,37] Best cultivation and extraction practices for MP have been documented well in Bangladesh, China, India, Nepal, Pakistan, Myanmar, and Indonesia.[38,39] Research and policy interventions in context with cultivation, extraction, commercialization, and their contribution to economy remain unclear on account of scanty knowledge about MPs.[40]

Indian Himalayan Region (IHR): Biodiversity Hotspot of MP

The IHR, which constitutes one of the 36 global biodiversity hotspots, is a home of rich yet unexplored MPs.[41] The unique topography and agro-climatic conditions are the major anchors of IHR, pointing to an under-utilized therapeutic sector which necessarily is based on holistic wellness of our ancient Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) approach.[42]

Indian Subcontinent is said to possess 45,000 plant species constituting nearly 20% of the global counterparts. Of these, about 3500 species of both higher and lower plant groups are powerhouses of bioactive compounds possessing therapeutic values. IHR is home to more than 8000 species of vascular plants,[43] of which 1748 are known for their therapeutic

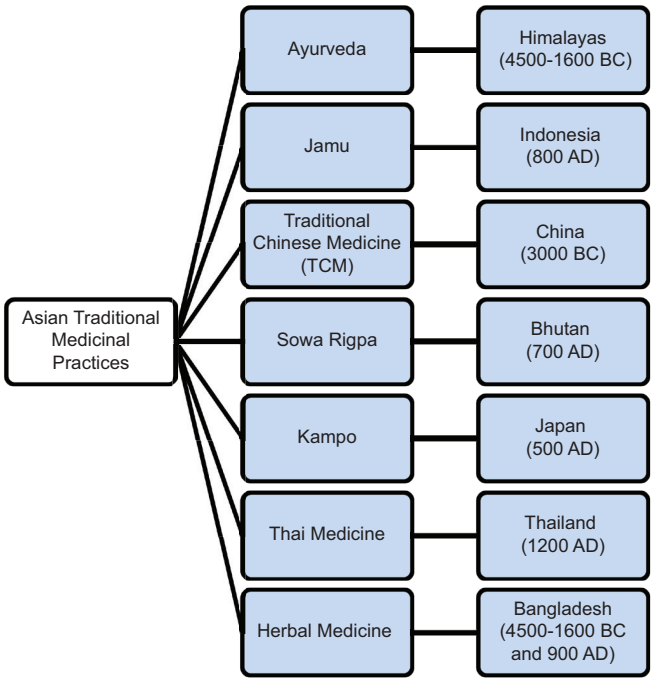

Figure 2: Asian traditional medicinal practices

value.[44] Figure 3 elucidates a vivid account of IHR which constitutes about 18% of India, encompassing more than 2,800 km length with 220 to 300 km width and altitudes ranging from 200 to 8000 m.[45-47] They are identified on the basis of their medicinal importance, commercial value, and potential for further research. Following [Tables 1-3] enlist MPs based on their commercial, therapeutic, and research value, respectively.[48]

Noteworthy is the fact that irrespective of species richness, the diversity of the innate, endemic, and near-endemic species has been found to increase with altitude. This is reflective of relatively less anthropogenic pressure on the higher altitude habitats, whereas a reverse trend is observed in the diversity of non-native MPs. This may be attributed to an increasing trend of anthropogenic activities on the natural habitats and invasion by non-native species at lower elevations. A study conducted by All India Trade Survey of prioritized MPs pointed out that there has been a reverse trend of demand (50%) versus supply (26%) demand for some high-value MPs has increased 50%, whereas availability has declined by 26%.[49] An ever-increasing demand for these species in pharmaceutical-industrial corridor has contributed to extensive degradation of habitat. This has led to need-based intervention for *in situ* conservation practices. NGOs and pharmaceutical industries have led to the development of herbal gardens and MP nurseries. Recently, the State MP Board was established to promote the MPs sector as a fundraising platform to boost conservation practices. With advent of agro-biotechnological interventions, notably MPs of IHR include *Saussurea costus*, *Humulus lupulus*, *Artemisia maritima*, *Bunium persicum*, *Carum carvi*, *Podophyllum hexandrum*, *Inula racemosa*, *Angelica*

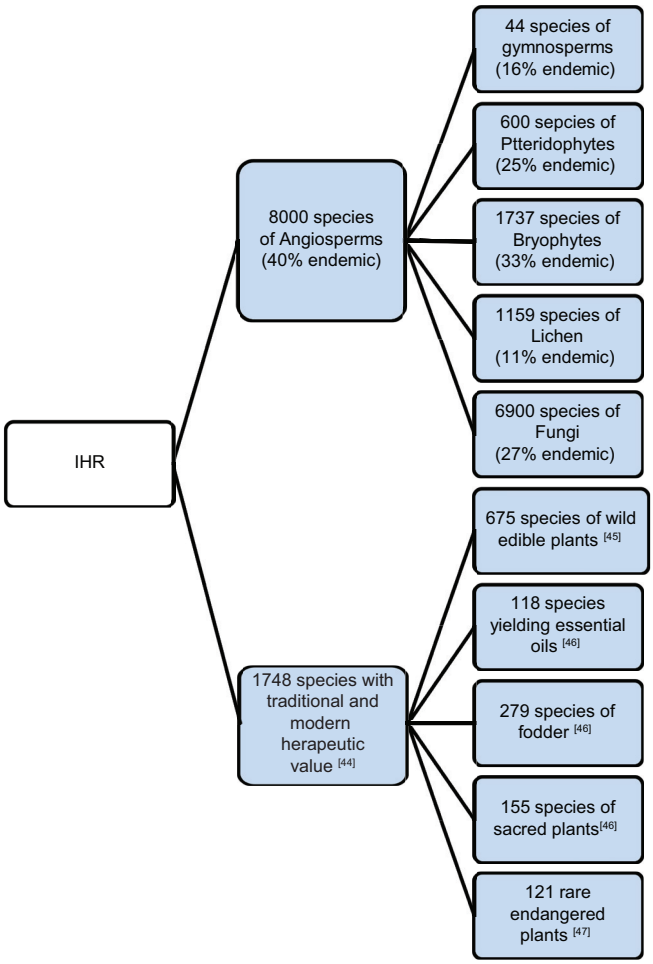

Figure 3: Indian Himalayan Region: A home to multitude of medicinal plant

glauca, *Acorus calamus*, *Heracleum candicans*, *Dioscorea deltoidea*, *Valeriana jatamansi*, *Picrorhiza kurroa,* and *Hedychium spicatum* have been cultivated by NGO led farmer groups.[50]

MPS AND ECONOMIC TRENDS: A DIFFUSED SCENARIO

An ever-increasing demand of herbal medicines by both developed and developing nations has propagated interest in pharmaceutical bio prospective green medicine.[51] On the contrary, dearth of national legislation, implementation policies, and effective international agreements on conservation and sustainable use of biodiversity has introduced the concept of "*Slaughter harvesting*" which has been concomitant with biodiversity losses. India, with approximately 8 % of global MPs reserves, has the potential of becoming a global hub for MPs-based herbal formulations, therapeutic, and personal care products. Farm-level cultivation is one of the focused interventions for catering toward ever-increasing demand of MPs. With varied agro-climatic conditions across Indian subcontinent,

not all MPs can be cultivated. It is ascertained that role of agro-climatic conditions on the chemical composition and therapeutic properties of MPs are well recognized and documented in Ayurveda.[52] Depending upon technological inputs and institutional arrangements, species-specific MPs cultivation is considered. Figure 4 justifies roles of different stakeholders as an integrated approach leading towards a sustained economic model.

CONTRACT FARMING (CF): A LUCRATIVE SUSTAINED APPROACH

CF is the production and supply system of both agricultural and horticultural produce by local farmers under forward contracts. This committed approach is a product-specific system which delivers at a specified price and quantity to a known buyer. This system has undoubtedly proven to be a vehicle of modernized and mechanized agricultural practices. Given the paradox picture of Indian agriculture scenario, CF has led to the inception of linkage between farm produce and market. There is no standard and homogenous method in CF in agriculture. In Indian context, permission to option contracts on commodities is yet to be attained, even though the Security Exchange Board of India has considered their introduction implicitly. Three types of CF exist [Figure 5].[53,54]

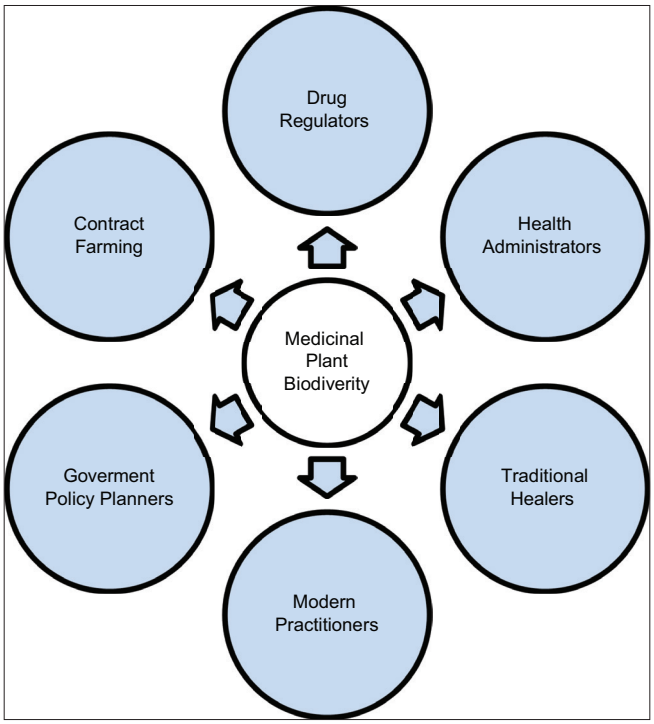

Figure 4: Medicinal plants diversity and stakeholders involved

Concept of Value Chain (VC) in MPs

Consideration of MP as an "Economic Sector" came into existence after inception of National MPs Board (NMPB) in 2000, set up under Government Resolution No. Z.18020/19/97-M.P.Cell notified on November 24, 2000 under the Chairpersonship of Union Health and Family Welfare Minister). Unfortunately, with ongoing critical research gap, there is a regrettable absence of research community working on socio-economic and policy aspects of MPs, such as that which exists with regard to agro-technology, biotechnology, etc.

NGOs act as a catalyst in promoting cultivation and marketing of MPs. Distribution of MPs involves consortium of activities such as primary collector, producer, local wholesaler, and specialized marketers.[55] Herbal industry is pivotal in cultivation of medicinal herbs which contributes to sustained economic models.[56]

A crucial understanding of how a market operates for a particular good is what lies in a concept of a VC.[57] It also ascertains a conceptual framework of the value-adding activities which a product undergoes from the initial stages of production to final delivery to end-user.[58,59] Mapping strategy also enables identification of the key players and their definite roles. This can lead to the improvement of chain structure through exclusions, inclusions, or building bridges. A successful VC model for MPs cultivated by rural communities has been proposed which is based on industry-community partnership. Furthermore, the concept of public-private partnership has been proposed

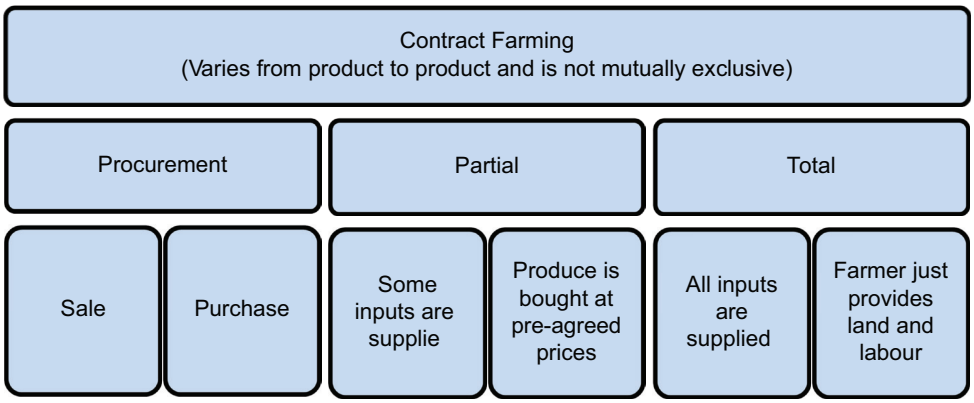

Figure 5: Types of contract farming

as an efficient, commercially viable, and sustainable VC mechanism for cultivators and manufacturers of agricultural products.[60,61] Proposed exploratory views on global trends have concluded that "mere matchmaking between producers and processors makes VC a buyer-driven one which tends to be exploitative, extracting as much resources and demanding lesser price from supplier." Given this situation,[62] corroborates the role of a bio-partnership that creates a linkage between industry and the producer community. A sustainable VC of MPs has been implemented in North India by establishing collaboration among farmers, research organizations, and industry.[63] A concept has been proposed for sustenance in MP sector [Figure 6].

Research in VC has been bi-focused. VC offers a competitive edge in market by how a product is processed or enriched by value addition for monetary gains.[64] It has been used as a tool for understanding socio-economic benefits, disadvantages, and associated market risks across all components of a VC. WHO has estimated that by 2050 MP and its allied trade activities will escalate up to US$ 5 trillion.[65] Strategically, Global VC can help us understand impacts associated with the production and manufacturing of herbal products, external and internal linkages within limits of production and trade networks. Ethnographical-focused VC from South America has been studied by Selwyn.[66]

A probabilistic and optimistic VC model in Bangladesh has been deciphered as vertical integration (VI).[67] The model suggests that integration is required to benefit both the producers and processors level at the initiation of a VC. Few identifiable gaps have led to the inception of an idea that the primary and wholesale secondary markets were captured by middlemen. This summed up the fact that cultivation of MPs was meant for economically stronger sections of society who possessed better access to land, capital, and information. Arguably, integrating institutional relationships may also lead to overall sustenance in VC of MP. Attributes of VI are depicted in Figure 7.

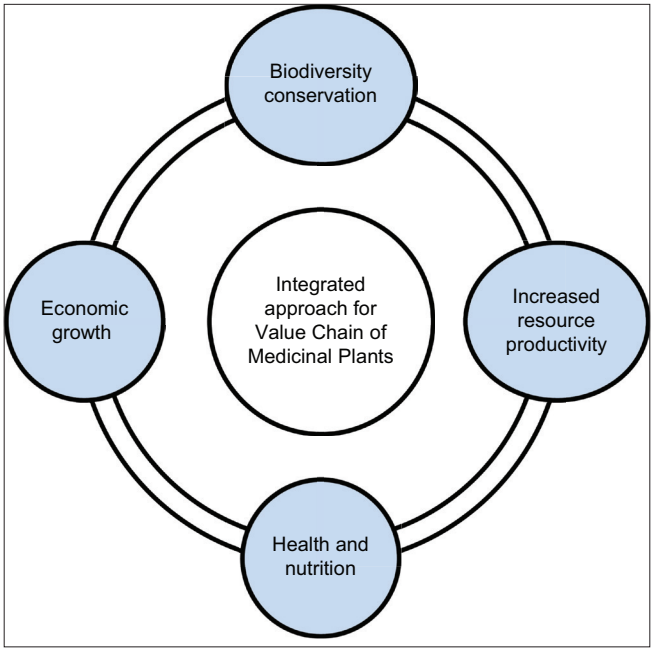

Figure 6: Integrated approach for value chain of medicinal plants

This model majorly enables active participation of primary producers to eliminate market access barriers which lead to the improved commercial potential of products by the rural poor leading to livelihood generation.[2] In addition, sensitization and self-driven motivation regarding resource management, reinvestment, and innovative practices for a resilient VC have been reported.[68] This is made possible through the competitive development of industries, local empowerment, and good governance (i.e., power and decision-making capacity). During this process, projection of strengthened relationships between primary producers and product manufacturers is undermined. On the contrary, they can facilitate and nurture information sharing platforms, de-escalating market barriers, sustainable use of natural resources, and effective natural resources management. An organized MP cultivation and its management would result in profitable returns for the small-scale growers.[69] That being said, commercial cultivation leading to large-scale produce can attract companies because they have greater control over quality and supply chain systems.[70] Figure 8 depicts different conceptual models in MP.[71]

A simple Model (A) is based on ethnopharmacological approach for connecting "*traditional healer*" to the patient considering indigenous knowledge systems of traditional

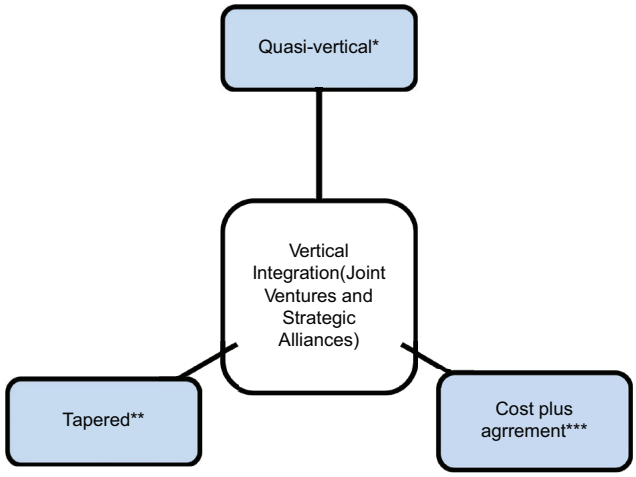

Figure 7: Vertical Integration model for sustenance in value chain of medicinal plant. *Quasi-vertical integration: especially close and long-term relationship. **Tapered vertical integration: External inputs from suppliers. ***Cost plus agreement: Negotiated amount is paid to contractors regardless of expenses incurred

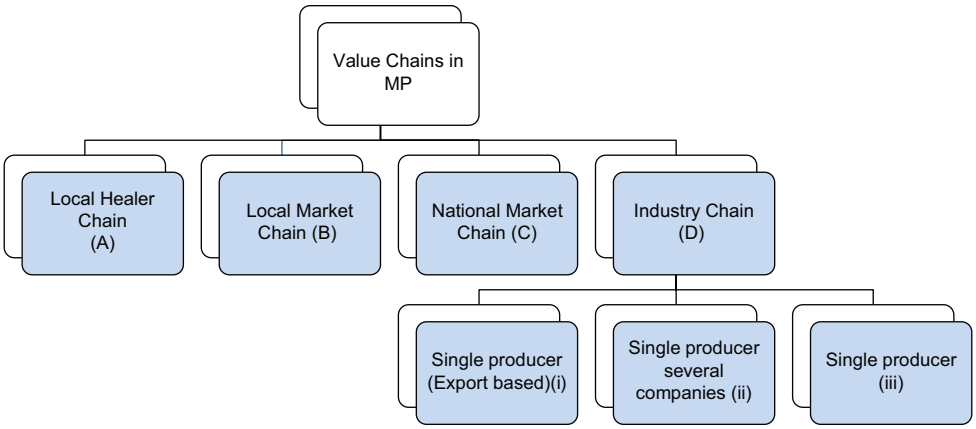

Figure 8: Probabilistic and conceptual value chain models of medicinal plant

medicine. Usually, the practitioner prescribes a formulation (bioactive ingredient) or a part of plant for the ailment. This is based on culturally acceptable community systems with ingrained beliefs. B model is an extension of A wherein the healer looks for local trading platforms which might be small-scale cultivation of MP or procurement of raw material from local traders. This approach has an impact on product quality and it is subsequent monitoring with economic benefits by offering a specific treatment cost. Hence, both these conceptual frameworks rely on local networking and reliability between the partners. In Model C and D, the role of middlemen comes into play who acts as a bridge between primary producer (farmer) and a retailer or an end-user. The middlemen procure raw material/product in bulk from producers and supply it nationally. This concept is customized and need-based as middlemen build up a supply chain or act as money lenders. Main difference between model C and D is that in D the consumers are integrated into global or international market structures to create a value proposition. In Model E, single producer with multiple companies are involved in supply chain with tapered VI. A similar approach is projected in Model F, where a single company can own multiple supply chains; usually placed at end of the chain (Pharmaceutical industry). This is seemingly the best model of VI; taking into consideration the value inputs, quality standards of finished products without undergoing monetary losses, and obvious to the fact that role of middlemen is eliminated. Value proposition of each VC model is validated by set of parameters depicted in Figure 9.

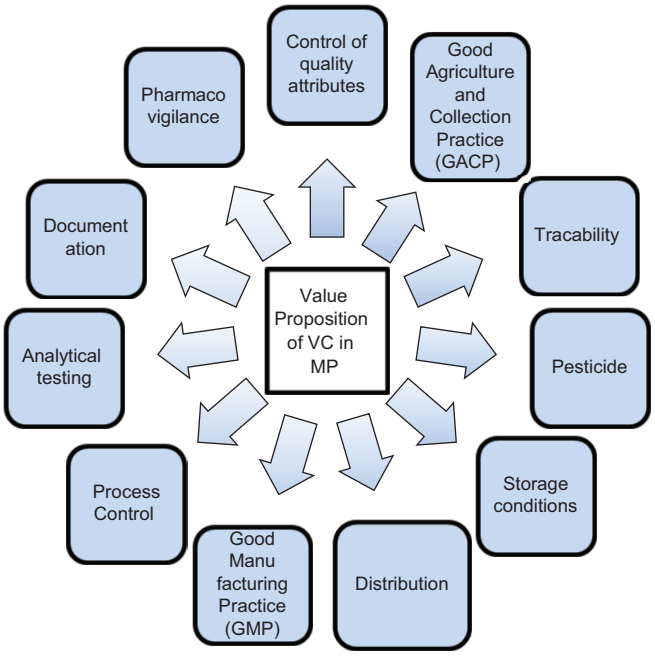

Figure 9: Parameters to validate efficacy of value chain in medicinal plant

DISCUSSION

Of almost 17,000 higher plants of Indian origin, approximately 10,000 are found to possess medicinal properties. It is perceived that 1200–1500 amongst them are used as bioactive compounds in ayurvedic formulations.[72] Major players in Ayurvedic medicine which have a handholding up to 85% of the domestic market are Dabur, Baidyanath, and Zandu. It has been reported that there is a market presence of more than 20 herbal drug manufacturing units and under 200 Small and Medium Enterprises (SMEs). In addition, traditional healers commonly referred to as Vaidyas possess their own minuscule herbal processing plants. Modus operandi of The Indian Traditional Herbal Medicines Act, 2006 states that traditional herbal medicines cannot be marketed without possession of any license.[73] Until recently, scheme launched by AYUSH Ministry to boost MP cultivation was a classic example of newer policies for promotion of cultivation of horticultural produce.[74] NMPB current plan envisages to embark 2.25 Lakh hectare area under MP cultivation. With a financial outlay of Rs 4,000 crore,

Table 1: MPs on the basis of their commercial value[48]

S. No.	Plant	Common Name
1	*Adhatoda zeylanica*	Vasaka
2	*Pluchea lanceolata*	Rasna
3	*Saraca indica*	Ashoka
4	*Terminalia*	Chebula
5	*Terminalia arjuna*	Arjun
6	*Azadirachta indica*	Neem

Table 2: MPs on the basis of their therapeutic value[48]

S. No	Plant	Common Name
1	*Plantago ovata*	Isabgol
2	*Bacopa monnieri*	Brahmi
3	*Centella asiatica*	Mandukaparni
4	*Withania somnifera*	Ashwagandha
5	*Andrographis paniculata*	Kalmegh
6	*Swertia chirata*	Chirayta
7	*Tinospora*	Guduchi
8	*Emblica*	Amla
9	*Commiphora wightii*	Guggul
10	*Phyllanthus amarus*	Bhumyamalaki
11	*Podophyllum*	Papra
12	*Asparagus racemosus*	Shatavari
13	*Picrorhiza kurroa*	Kutki
14	*Streblus asper*	Shakhotaka

Table 3: MPs on the basis of their research potential[48]

S. No	Plant	Common Name
1	*Holarrhena*	Kutaja
2	*Crataeva nurvala*	Varun
3	*Valeriana jatamansi*	Tagar
4	*Vilo odorata*	Banafsha
5	*Aconitum*	Ativisha
6	*Aloe barbadensis*	Ghrita
7	*Ocimum sanctum*	Tulsi

10,00,000 hectares of land is planned to be cultivated under this scheme in the next 2 years. It is anticipated to raise Rs 5,000 crore as a source of income generation for farmers leading to the development of regional mandis for MP.[75] Certain implementation strategies have been proposed to improve VC of MP [Figure 10].[76]

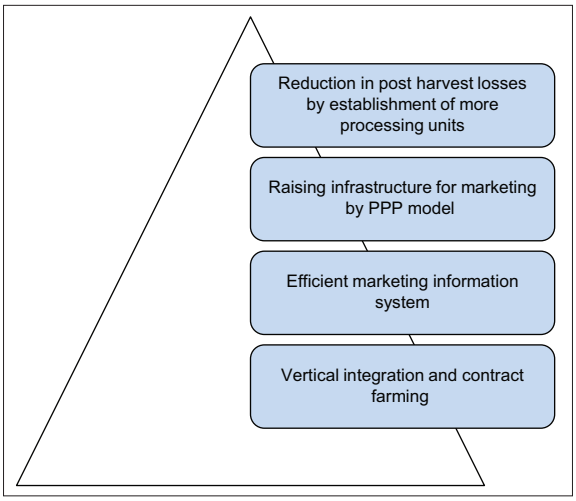

Figure 10: Implementation strategies to improve value chain of medicinal plant

CONCLUSION

India has a unique yet inevitable concept of "marketing" herbal goods. Small companies, including neighborhood pharmacies, collaborate to formulate their own remedies based on indigenous knowledge systems. Department of AYUSH within the Ministry of Health and Family Welfare is focused to regulate and improve standards of quality control, drug standardization, improving the availability of raw materials, research, and development, capacity building, and education/training of professionals. Pharmacopoeia Committees have been proved to be a benchmark for the main groups of therapeutically bio-active components (drugs) of Ayurveda, Unani, Siddha and Homoeopathy. The Indian Government also established an independent body – the "National Medicinal Plants Board" under the Ministry of Health and Family Welfare which co-ordinates with issues related to MP cultivation, post-harvest strategy, processing, establishment of AYUSH clusters, quality control of raw materials, and policy framework for innovative R and D framework by nurturing a cohesive approach between stakeholders including farmers, NGOs, research institutes, industrial clusters, healthcare practitioners, and community at large. This platform would essentially improvise the existing VC for MP in India and strengthen its export potential by establishing sustenance across industrial sectors. Uniquely, the very concept of green therapeutics needs to be harnessed given the current scenario when burning issues like antimicrobial resistance are manifesting their adversities and toxicological implications not only in healthcare sector but at environmental landscape at large.

AUTHORS' CONTRIBUTIONS

Neha Sharma

- Data curation and conceptualization
- Writing-original draft

- Writing-review and editing
- Formal analysis
- Validation

Vipin Saini
- Administrative approvals

ACKNOWLEDGMENTS

The authors would like to thank MM University, Solan, for providing necessary resources.

REFERENCES

1. Badalingappanavar R, Hanumanthappa V, Shashikala K, Gajendra K. Organic fertilizer management in cultivation of medicinal and aromatic crops: A review. J Pharmacogn Phytochem 2018;3:126-9.
2. Phondani PC, Maikhuri RK, Bisht NS. Endorsement of ethnomedicinal knowledge towards conservation in the context of changing socio-economic and cultural values of traditional communities around Binsar wildlife sanctuary in Uttarakhand, India. J Agric Environ Ethics 2013;26:573-600.
3. Yang L, Ahmed S, Stepp JR, Zhao Y, Ma J, Liang C, *et al*. Comparative homegarden medical ethnobotany of naxi healers and farmers in Northwestern Yunnan, China. J Ethnobiol Ethnomed 2014;10:6.
4. Nagaraju K, Vishwanath M, Aruna K. Seed quality enhancement techniques in medicinal and aromatic crops. J Pharmacogn Phytochem 2018;3:104-9.
5. Keshari P, Pradeep. A review of conservation and sustainable use of medicinal plant with special reference of *Tecomella undulata* (Sm.) Seem. J Pharmacogn Phytochem 2018;3:9-13.
6. González-Minero J, Bravo-Díaz L. The use of plants in skin-care products, cosmetics and fragrances: Past and present. Cosmetics 2018;5:50.
7. Moran D, Kanemoto K. Identifying the species threat hotspots from global supply chains. Nat Ecol Evol 2017;1:076869.
8. World Health Organization. Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants. Geneva: World Health Organization; 2003. Available from: http://www.whqlibdoc.who.int/publications/2003/9241546271.pdf. [Last accessed on 2011 Sep 24].
9. Vandecandelaere E, Teyssier C, Barjolle D, Jeanneaux P, Fournier S, Beucherie O. Strengthening Sustainable Food Systems Through Geographical Indications: An Analysis of Economic Impacts. Rome, Italy: Food and Agriculture Organization; 2018.
10. Manzanilla V, Kool A, Nhat LN, Nong Van H, Thu H, De Boer HJ. Phylogenomics and barcoding of Panax: Toward the identification of ginseng species. BMC Evol Biol 2018;18:44.
11. Gao Z, Liu Y, Wang X, Wei X, Han J. DNA mini-barcoding: A derived barcoding method for herbal molecular identification. Front Plant Sci 2019;10:1-11.
12. Techen N, Parveen I, Pan Z, Khan IA. DNA barcoding of medicinal plant material for identification. Curr Opin Biotechnol 2014;25:103-10.
13. Hollingsworth PM, Li DZ, van der Bank M, Twyford AD. Telling ant species apart with DNA: From barcodes to genomes. Philos Trans R Soc Lond B Biol Sci 2016;371:20150338.
14. Coissac E, Hollingsworth PM, Lavergne S, Taberlet P. From barcodes to genomes: Extending the concept of DNA barcoding. Mol Ecol 2016;25:1423-8.
15. Andrews KR, Good JM, Miller MR, Liukart G, Hohenlohe PA. Harnessing the power of RADseq for ecological and evolutionary genomics. Nat Rev Genet 2016;17:81-92.
16. Ruhsam M, Rai HS, Mathews S, Ross TG, Graham SW, Raubeson LA, *et al*. Does complete plastid genome sequencing improve species discrimination and phylogenetic resolution in *Araucaria*? Mol Ecol Resour 2015;15:1067-78.
17. Ick-Hyun J, Kyong-Hwan B, Chi-Eun H, Jang-Uk K, Jung-Woo L, Dong-Hwi K, *et al*. Analysis of the chloroplast genome and SNP detection in a salt tolerant breeding line in Korean ginseng. J Plant Biotechnol 2016;43:417-21.
18. Kreuzer M, Howard C, Adhikari B, Pendry CA, Hawkins JA. Phylogenomic approaches to DNA barcoding of herbal medicines: Developing clade-specific diagnostic characters for *Berberis*. Front Plant Sci 2019;10:586.
19. Anantha DB, Johnson ST. DNA barcoding in authentication of herbal raw materials, extracts and dietary supplements: A perspective. Plant Biotechnol Rep 2019;13:201-10.
20. Sarrazola HJ, Alzate FA. Obtaining DNA from Urticaceae: Overcoming the challenges associated with chemical compounds and herbarium specimens. Int J Mol Biol 2019;4:158-65.
21. Kozarewa I, Armisen J, Gardner AF, Slatko BE, Hendrickson CL. Overview of target enrichment strategies. Curr Protoc Mol Biol 2015;112:23.
22. Schmickl R, Liston A, Zeisik V, Oberlander K, Weiteimir K, Straub SC, *et al*. Phylogenetic marker development for target richment from transcriptome and genome skim data: The pipeline and its replication in Southern African *Oxalis* (*Oxalidaceae*). Mol Ecol Resour 2016;16:1124-35.
23. He K. Traditional Chinese and Thai medicine in a comparative perspective. Complement Ther Med 2015;23:821-6.
24. Torri MC. Linking small-scale commercial activities and women's health: The Jamu system in urban areas of Java, Indonesia. J Small Bus Manage 2016;54:341-55.
25. Torri MC, Herrmann TM. Bridges between Tradition

and innovation in ethnomedicine. In: Fostering Local Development Through Community-based Enterprises in India. Heidelberg, Germany: Springer; 2011.
26. Roy Upton RH. Traditional herbal medicine, pharmacognosy, and pharma-copoeial standards: A discussion at the crossroads. In: Mukherjee PK, editor. Evidence Based Validation of Herbal Medicine. Amsterdam, Netherlands: Elsevier; 2015.
27. Zhao X, Zheng X, Fan TP, Li Z, Zhang Y, Zheng J. A novel drug discovery strategy inspired by traditional medicine philosophies. Science 2015;347:S38-40.
28. Cordell GA. Sixty challeneges-A 2030 perspective on natural products and medicines security. Nat Prod Commun 2017;12:1371-9.
29. Jeelani SM, Rather GA, Sharma A, Lattoo SK. In perspective: Potential medicinal plant resources of Kashmir Himalayas, their domestication and cultivation for commercial exploitation. J Appl Res Med Aromat Plants 2018;8:10-25.
30. Karunamoorthi K, Jegajeevanram K, Vijayalakshmi J, Mengistie E. Traditional medicinal plants: A source of phytotherapeutic modality in resource-constrained health care settings. J Evid Based Complement Altern Med 2013;18:67-74.
31. Munasinghe M. Making Development More Sustainable: Sustainomics Framework and Practical Applications. Colombo, Sri Lanka: MIND Press; 2010.
32. Jamshidi-Kia F, Lorigooini Z, Amini-Khoei H. Medicinal plants: Past history and future perspectives. J Herb Med Pharmacol 2018;7:1-7.
33. Ten Kate K. The commercial use of biodiversity. In: Access to Genetic Resources and Benefit-Sharing. London, UK: Earthscan; 2000.
34. Foodtank Health of Medicinal Plants at Risk. Available from: https://www.foodtank.com/news/2014/11/healthofmedicinal-plants-at-risk. [Last accessed on 2017 Mar 21].
35. Vasisht K, Sharma N, Karan M. Current perspective in the international trade of medicinal plants material: An update. Curr Pharm Des 2016;22:4288-336.
36. Chi X, Zhang Z, Xu X, Zhang X, Zhao Z, Liu Y, *et al*. Threatened medicinal plants in China: Distributions and conservation priorities. Biol Conserv 2017;210:89-95.
37. Phumthum M, Srithi K, Inta A, Junsongduang A. Ethnomedicinal plant diversity in Thailand. J Ethnopharmacol 2017;214:90-8.
38. Rashid AZ, Manzoor H, Tunon NA, Khan SA. Commercial cultivation by farmers of medicinal plants. Eur J Environ Sci 2014;4:60-8.
39. Timmermann L, Hall CS. Commercial medicinal plant collection is transforming high altitude livelihoods in the Himalayas. Mount Res Dev 2019;39:R13-21.
40. Astutik S, Pretzsch J, Kimengsi JD. Asian medicinal plants' production and utilization potentials: A review. Sustainability 2019;11:5483.
41. Samal J. Medicinal plants and related developments in India: A peep into 5-year plans of India. Indian J Health Sci Biomed Res 2016;9:14-9.
42. Sharma S, Raina A, Agrawal DC, Dhar MK, Kaul S. Neurotoxic medicinal plants of Indian Himalayan regions: An overview. In: Agrawal DC, Dhanasekaran M, editors. Medicinal Herbs and Fungi. Singapore: Springer; 2021.
43. Singh DK, Hajra PK. Floristic diversity. In: Gujral GS, Sharma V, editors. Biodiversity Status in the Himalaya. New Delhi: British Council; 1996. p. 23-38.
44. Samant SS, Dhar U, Palni LM. Medicinal Plants of Indian Himalayas: Diversity, Distribution, Potential Values. Almora, Uttaranchal, India: G.B. Pant Institute of Himalayan Environment and Development; 1998.
45. Samant SS, Dhar U. Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. Int J Sust Dev World 1997;4:179-91.
46. Samant SS, Pal M. Diversity and conservation status of medicinal plants in Uttaranchal State. Indian Forest 2003;129:1090-108.
47. Nayar MP, Sastry AR. Red Data Book of Indian Plants. Vol. I-III. Calcutta: Botanical Survey of India; 1990.
48. Kuipers SE. Trade in Medicinal Plants: Medicinal Plants for Forest Conservation and Healthcare, Non-wood Forest Products 11. United Nations, Rome: Food and Agriculture Organization; 1997.
49. Anonymous. Appendix I, II and III to Convention on International Trade in Endangered Species of Wild Fauna and Flora. Arlington VA: US Fish and Wildlife Services; 2001.
50. Butola JS, Badola HK. Threatened Himalayan medicinal plants and their conservation in Himachal Pradesh. J Trop Med Plants 2008;9:125-42.
51. Rathore S, Sashni S, Sharma A, Sundriyal RC. Ethnobotanical study on medicinal plants used by the tribal people of Lahaul and Spiti district, Himachal Pradesh, North-Western Himalaya. Indian Forest 2019;145:8.
52. Pan SY, Litscher G, Gao SH, Zhou SF, Yu ZL, Chen HQ, *et al*. Historical perspective of traditional indigenous medical practices: The current renaissance and conservation of herbal resources. Evid Based Complement Alternat Med 2014;2014:525340.
53. Federgruen A, Lall U, Simsek SA. Supply Chain analysis of contract farming. Manuf Serv Oper Manage 2019;21:361-78.
54. Rajib P. Indian agricultural commodities derivates market-in conversation with S Sivakumar, divisional chief executive, agri business division, ITC Ltd. IIMB Manage Rev 2015;27:118-28.
55. Joshi P, Rao N. Role of indigenous people in conservation of biodiversity of medicinal plants: An Indian case study. Survival Sustain 2011;2011:91-101.
56. Carabine E, Simonet C. Value Chain Analysis for Resilience in Drylands (VC-ARID): Identification of Adaptation Options in Key Sectors VC-ARID Synthesis Report, Working Paper. Africa: Pathways to Resilience in Semi-Arid Economies (PRISE); 2018.

57. Doan T. Supply chain management drivers and competitive advantage in manufacturing industry. Uncertain Supply Chain Manage 2020;8:473-80.
58. Reddy AA. Training Manual on Value Chain Analysis of Dryland Agricultural Commodities. Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); 2013. p. 88.
59. Gidey MH, Asfaw Z, Gidey M. Review on value chain analysis of medicinal plants and the associated challenges. J Med Plants Stud 2016;4:45-55.
60. Marbaniang EK, Chauhan JK, Kharumnuid P. Public private partnership (PPP) in agriculture: A step towards sustainable agricultural development. Agric Food 2020;2:387-90.
61. Chhabra T. Value Chain analysis for medicinal plant based products in India: Case study of Uttarakhand. Arch Organic Andinorg Chem Sci 2018;4:449-57.
62. Karki M. Development of Bio-partnership for Sustainable Management of Medicinal and Aromatic Plants in South Asia. New Delhi: IDRC-20MAPPA; 2000. Available from: https://lib.icimod.org/record/20321?ln=fr. [Last accessed on 2006 Dec].
63. Nautiyal MC, Nautiyal BP. Collaboration between farmers research institutions and industry: Experiences of *Picrorhiza kurroo* cultivation at Gheshe village in Chamoli District, Uttaranchal. In: Searching Synergy: Stakeholders Views on Developing a Sustainable Medicinal Plants Chain in Uttaranchal, India, KIT Bulletin No. 359. Amsterdam: KIT Publishers; 2004.
64. Pagaria P, Jain LK. Value chain study of medicinal plant Shankhpushpi (*Convolvulus pluricaulis)* in Barmer district of Rajasthan. J Med Aromatic Plant Sci 2020;42:250-6.
65. Tee LH, Yang B, Nagendra KP, Ramanan RN, Sun J, Chan ES, *et al*. Nutritional compositions and bioactivities of *Dacryodes* species: A review. Food Chem 2014;165:247-55.
66. Selwyn B. Labour process and workers' bargaining power in export grape production, North East Brazil. J Agrar Change 2007;7:526-33.
67. Shahidulla AK, Haque EC. Linking medicinal plant production with livelihood enhancement in Bangladesh: Implications of a vertically integrated value chain. *J* Transdiscip Environ Stud 2010;9:1-18.
68. Volenzo T, Odiyo J. Integrating endemic medicinal plants into the global value chains: The ecological degradation challenges and opportunities. Heliyon 2020;6:e04970.
69. Chengappa PG. Development of agriculture value chains as a strategy for enhancing farmers' income. Agric Econ Res Rev 2018;31:1-12.
70. Noorhosseini SA, Fallahi E, Damalas CA. Promoting cultivation of medicinal and aromatic plants for natural resource management and livelihood enhancement in Iran. Environ Dev Sustain 2020;22:4007-24.
71. Booker A, Johnston D, Heinrich M. Value chains of herbal medicines-research needs and key challenges in the context of ethnopharmacology. J Ethnopharmacol 2012;140:624-33.
72. Kumar S, Dobos GJ, Rampp T. The significance of ayurvedic medicinal plants. Evid Based Complement Altern Med 2017;22:494-501.
73. Sahoo N, Manchikanti P. Herbal drug regulation and commercialization: An Indian industry perspective. J Altern Complement Med 2013;19:957-63.
74. Available from: https://www.health.economictimes.indiatimes.com/news/industry/central-scheme-announced-to-boost-cultivation-of-medicinal-plants/78032641. [Last accessed on 2020 Dep 10].
75. Available from: https://www.health.economictimes.indiatimes.com/news/policy/ganga-river-banks-now-part-of-rs-4000-cr-plan-for-herbal-cultivation/75773699. [Last accessed on 2020 May 15].
76. Rathore R, Mathur A. Scope of cultivation and value chain perspectives of medicinal herbs in India: A case study on aloe Vera and Isabgol. J Pharmacogn Phytochem 2019;8:243-6.

Source of Support: Nil. **Conflicts of Interest:** None declared.