POLICY PAPER

79

Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for Small Farmers

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Preface

Current global trade of medicinal and aromatic plants (MAPs) is around US$ 62 billion, and is projected to reach US$ 5 trillion by 2050 and our country can take advantage of this growing trade. With its diverse agro-climatic conditions India is home to a large number of MAPs. There are at least 35 major Medicinal and Aromatic Crops (MACs) which have an established global demand and can be cultivated in India. Organized cultivation of MACs, therefore, is the need of hour as 90% of such plant material, used by pharmaceutical and aroma industry is collected from the wild sources that are dwindling at an alarming rate. Integration of MACs in traditional cropping systems can produce medicinal herbs and essential oils at competitive prices, which not will only help small farmers to earn extra income but also enable the herbal drug and essential oil industry in our country to become more competitive in global markets.

While research and development in the cultivation and processing of MACs has progressed well in India due to the efforts of R&D organizations, but value-chain management of this sector has not received the desired attention so far. A close coordination and harmony among researchers, industry and policy makers is required to achieve these goals.

It was in this back-drop that the National Academy of Agricultural Sciences (NAAS) organized a Brainstorming Session on 'Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for Small Farmers". The primary focus of the BSS was to consolidate the available knowledge base, research out-puts, industrial activities and cultivation opportunities of MACs in the country so as to prepare a policy framework and road map for the organized growth of the herbal sector in the country. I am confident that this Policy Document will be a useful advisory in deciding research priorities, strategic planning and take informed decisions that would help all stakeholders of MACs to align their action plans suitably. The academy appreciates the efforts of Prof A.K. Tripathi and Dr E.V.S. Prakasa Rao for convening this important session. The Academy also thanks all the participants, resource persons, reviewers and editors for their valuable contributions in the preparation of this policy document.

S. Ayyappan
President

Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for Small Farmers

1. INTRODUCTION

Traditionally, the Indian agriculture largely revolves around cultivating food and horticultural crops like cereals, pulses, oil seeds, vegetables, fruits, flowers and other cash crops like cotton, sugarcane and spices on irrigated, semi-irrigated and non-irrigated / rainfed areas. Increasing demand for such crops produced in the back-drop of diminishing land / water resources, habitat degradation and increasing weather extremes, therefore, demands that Indian agriculture may diversify in two directions. Firstly, the expansion of agriculture to sub-optimally utilized forests and degraded soils covering deserts, wastelands and coastal regions and secondly, cultivation of certain other useful short-duration non-agricultural crops that can easily fit into the existing cropping systems as sole, mixed or inter-crops with agricultural and horticultural crops to generate additional income for farmers from unit area of land and time. Medicinal and aromatic crops with well established industrial demand in domestic and global herbal trade represent a potential resource that can ideally fit into such technology integration efforts (Prakasa Rao 2009a,b; 2012).

Cultivation of medicinal and aromatic crops (MACs) is now gradually becoming an important avenue for additional income generation for Indian farmers, particularly those with small land holdings. Synergy among R & D institutions, farming community and industry has scripted impressive success stories in case of mint, basil, chamomile, isabgol, senna, ashwagandha and opium poppy cultivation to name a few examples. These remarkable developments, besides affording self-sufficiency, have placed India in a leadership position in global herbal trade of these products and contributed towards the upliftment of the economic status of a large number of farmers and entrepreneurs. Nearly five lakhs farming families in the country are presently engaged with mint cultivation in about 2,50,000 ha of land contributing to Rs. 3500-4000 crore annual turnover making India the largest global producer and exporter of menthol mint . Similarly, India is the largest producer and exporter of isabgol contributing 80% share in its global trade with an annual turnover of US$ 130-160 million. Earning from senna cultivation is also to the tune of Rs.200-250 crores per year. Besides being the only country to legally produce opium poppy for pharmaceutical purposes, India is expanding export of poppy seeds for culinary and confectionary industry, and exporting poppy seeds worth US $ 200 million annually. Therefore, the level of confidence, enthusiasm and optimism of the farmers to take up MACs cultivation in the

country has increased in the last decade. These successes must now be taken forward and leveraged for promoting other promising medicinal and aromatic crops which have global demand and assured market. Apart from limited value addition success in some species like mint, India remains essentially a raw material exporter of MAPs in the world trade despite the scale of production.

Identification and prioritization of high value medicinal and aromatic crops for their integration with traditional agriculture/horticulture crops may follow several criteria. These may include: the size of their annual market demand and potential agro-economic returns, herbs that are exclusively collected from wild through a predominantly destructive method of collection like *Swertia, Picrorrhiza, Podophyllum, Aconitum, Centella, Commiphora, Terminalia, Coscinium, Santalum, Valeriana, Rauvolfia, Jatamansi*, *Ocimum spp., Eyucalyptus* etc.; herbs that are source of bulk natural aroma molecules like linalool, methyl chavicol, menthol, eugenol and methyl cinnamate etc that can be easily converted into a variety of other fragrance and flavor derivatives; herbs that are used directly in the manufacture of a large number of herbal formulations like *Allium, Aloe, Hypericum, Terminalia, Emblica, Asparagus, Acorus, Pipali, Vasaka, Ashwagandha, Cyperus, Berberis, Tribulus, Holarrhena;* herbs that are exclusive source of high value phytomolecules that defy synthetic routes of production and; herbs like *Centella, Bacopa, Vetiver, Hype, Cymbopogon, Phyllanthus, Decalepsis* etc. that can phyto-remediate polluted or other environmentally stressed soils.

National Medicinal Plants Board (NMPB) in 2008 has listed 960 medicinal plants species that are traded in India. Out of these, 178 are identified as high volume species with more than 100 tonnes (dry weight) annual requirement. Only 36 of such species are sourced largely or entirely from cultivation. Important among these are: *Abelmoschus moschatus*, *Acorus calamus*, *Adhatoda zeylanica*, *Aloe barbedensis*, *Azadirachta indica*, *Cassia angustifolia*, *Catharanthus roseus*, *Cichorium intybus*, *Curcuma angustifolia*, *Curcuma zerumbet*, *Gloriosa superba*, *Indigofera tinctoria*, *Inula racemosa*, *Kaempferia galanga*, *Lawsonia inermis*, *Lepidium sativum*, *Ocimum basilicum*, *Ocimum tenuiflorum*, *Piper longum*, *Plantago ovata*, *Plectranthus barbatus*, *Pongamia pinnata*, *Saussurea costus*, *Silybum marianum*, *Trachyspermum ammi*, *Vitex negundo*, *Withania somnifera*, *Ziziphus jujube* etc. In addition, about 91 species in herbal trade are being sourced from the forest and majority of these are woody perennials or alpine herbs. Important among these are: *Abies spectabilis*, *Aconitum ferox*, *Aconitum heterophyllum*, *Berberis aristata*, *Bergenia ciliata*, *Ephedra gerardiana*, *Nardostachys grandiflora*, *Picrorhiza kurroa*, *Rheum australe*, *Swertia chirayita*, *Taxus wallichiana*, *Valeriana jatamansi*, *Viola pilosa*, *Aegle marmelos*, *Alstonia scholaris*, *Asparagus racemosus*, *Boswellia serrata*, *Butea monosperma*, *Chlorophytum tuberosum*, *Emblica officinalis*, *Garcinia indica*, *Gardenia resinifera*, *Gymnema sylvestre*, *Holarrhena pubescens*, *Ipomoea mauritiana*, *Morinda pubescens*, *Pterocarpus marsupium*, *Pterocarpus santalinus*, *Rauvolfia serpentina*, *Rubia cordifolia*, *Santalum album*, *Strychnos*

potatorum, *Terminalia arjuna*, *Terminalia bellirica*, *Terminalia chebula* etc. Interestingly, 46 of the high volume medicinal species in the herbal trade are obtained from the degraded landscapes and roadsides collections. Important among these species are: *Andrographis paniculata*, *Bacopa monnieri*, *Boerhavia diffusa*, *Cardiospermum halicacabum*, *Centella asiatica*, *Convolvulus microphyllus*, *Curculigo orchioides*, *Datura metel*, *Hemidesmus indicus*, *Ocimum americanum*, *Phyllanthus amarus*, *Plumbago zeylanica*, *Psoralea corylifolia*, *Sida rhombifolia*, *Solanum nigrum*, *Tinospora cordifolia*, *Vetiveria zizanioides*, *Withania coagulens* etc.

Baring a few medicinal and aromatic crops such as *Mentha arvensis* (menthol mint), *Cassia angustifolia* (senna), *Plantago ovata* (isabgol), *Papaver somniferum* (opium poppy), *Rosa damascena* (scented rose), sweet basil *(Ocimum basilicum)* aromatic grasses, *Withania somnifera* (ashwagandha) etc, the cultivation and trade of majority of medicinal and aromatic crops in India has so far been un-organized and by and large un-regulated. Collection and supply from the uncharacterized natural stands pre-dominates the herbal trade, that is threatening biodiversity and sustainable supplies. Supply chain mechanisms in this sector are underdeveloped with over-domination of middlemen and a few monopolistic wholesale dealers / industry. Farmers and cultivators of MACs often find themselves in vulnerable situations in the trading bargain in a fluctuating demand and supply scenario.

Despite several efforts by governmental and non-governmental organizations, many gaps still exist in the cultivation, financing and marketing of MACs. The trade in supply of raw herbs to pharmaceutical and aroma industries for preparing traditional as well as modern medicines, fragrances, flavors and other herbal formulations, has to be driven by quality, safety and consistency including price competitiveness. It is becoming increasingly imperative that R&D outcomes of different laboratories be delivered to farmers and end-user industries through a well-organized extension network. Integrated extension and dissemination programs must be launched to sensitize farmers, industry, development agencies and other partners in developing appropriate value chains. Financing and providing incentives like subsidies to the MACs farmers to encourage this sector is important issue that needs to be looked into by the policy-makers and the regional / national governments.

This policy paper has been prepared on the basis of a national dialogue held during a one day brain storming session on “Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for Small Farmers”, organized on 18 August, 2015 by National Academy of Agricultural Sciences (NAAS) at NASC, New Delhi. The session was attended by nearly thirty area experts from CSIR and ICAR institutes, agricultural universities, National Medicinal Plants Board, Spices Board, Ministry of Commerce, Flavours and Fragrances Development Centre, Ministry of Micro, Small and Medium Enterprises, Essential Oil

Association of India, industry representatives from Drug and Aroma Companies and progressive farmers of Uttar Pradesh and Tamil Nadu.

2. MEDICINAL AND AROMATIC CROPS CULTIVATION AND TRADE – CURRENT STATUS

The global herbal trade of medicinal and aromatic plants (MAPs) has been growing exponentially, and with an annual growth rate of 15% stands at US$ 62 billion mark today and is likely to touch a scale of US$ five trillion by 2050 (Sharma and Arora 2006; Kumari et al. 2011; Sen et al. 2011; Kunwar et al. 2013; Mathe 2015; www.dbtindia.gov.in). An estimated 400000 tonnes of MAPs are traded annually. The range of species that comprise the MAPs group probably extends to over 70,000 worldwide, of which 3,000 are widely traded as high value products in commerce. Of these, only around 900 species are cultivated and rest are sourced from the wild. While medicinal plants are normally sold in the market as crude drugs, semi-processed / standardized extracts or finished formulations / products, aromatic plants are mainly traded in the form of their steam-distilled essential oils and solvent-extracted concretes and absolutes. India's existing contribution to the present global herbal trade is meager and valuated at US$ 150 million annually (Prajapati and Prajapati 2005; Ved and Goraya 2008; Marichamy et al. 2014; Subramoniam 2014; Sen and Chakraborty 2015). It is largely accounted for by menthol mint oil, psyllium seed husk and senna leaves and pods. This situation needs improvement through appropriate strategies and logical scrutiny of current scenario. India exports its medicinal plants mainly (>80%) in the form of crude herbs rather than value-added finished products.

One of the most deterring factors behind India's poor market share in herbal trade has been the lack of quality consciousness of Indian herbal companies, for raw herbs that often results in batch to batch inconsistency in their finished products. More than 90% of the plant material used in pharma and aromatic industries is presently collected from non-descriptive, uncharacterized land races from forest and other wild resources. More often than not, such collections are usually made using destructive harvests from the wild stands that pose a serious threat to country's biodiversity. This is neither sustainable nor acceptable in a globally competitive scenario. In order to arrest extinction and rapid decline in the diversity of medicinal plants and to maintain a sustained supply of quality raw material for the production of herbal formulations, there is a pressing need for a change in the shift of our mind-set from "collection to cultivation" of MACs. There are at least 35 major medicinal plants that can be cultivated in different agro-climatic zones of the country and there is an established global demand for their raw produce and high-value bioactive principles. These include *Acorus calamus,*

Aconitum heterophyllum, Adhatoda vasica, Aloe vera, Ammi majus, Atropa accuminata, Berberis aristata, Carica papaya, Catharanthus roseus, Senna alexandrina (Cassia senna), Cephalis ipecacuanha, Colchicum luteum, Dioscorea deltoidea, Gycyrrhiza glabra, Hedychium spicatum, Hyoscyamus species, Inula racemosa, Chamomilla recutita (Matricaria chamomilla), Papaver somniferum, Plantago psyllium, Podophyllum hexandrum, Rauvolfia serpentina, Rheum emodi, Saussurea lappa, Valeriana wallichii, Withania somnifera, Zingiber officinale, Psoralea corylifolia etc. In addition to above, there are about a dozen more medicinal plant species with proven pharmaceutical potential and suitability for cultivation in diverse agro-climatic regions in India. Proper agrotechnologies for their cultivation need to be developed and popularized among farmers, these include *Andrographis paniculata, Boswellia serrata, Centella asiatica, Coleus forskohlii, Commiphora wightii, Picrorrhiza kurroa, Curcuma longa, Phyllanthus amarus, Sida rhombifolia and Taxus baccata.* Likewise, amongst the aromatic plants, cultivation of *Anethum graveolense, Artemisia pallens, Cymbopogon flexuosus, C. martinii, C. winterianus, Eucalyptus citriodora, Jasminum grandiflorum, Lavandula angustifolia, Mentha arvensis, M. cardiaca, M. citrata, M. spicata, M. piperita, Ocimum basilicum, Pelargonium* sp., *Pogostemon patchouli (cablin), Rosmarinus officinalis, Salvia sclarea, Vetiveria zizanioides,* etc. deserve priority attention due to the high local and international market demand for their essential oils.

The management of entire value-chain linked with research and promotion of organized cultivation, processing, financing and marketing of medicinal and aromatic crops and their products is a priority and should receive attention similar to other Priority Missions, related to skill development of rural youth. This will enable to generate additional income for marginal farmers, employment generation through entrepreneurships, gender equity through women participation and integration of AYUSH objectives in affordable health care system.

3. ISSUES TO BOOST MACS CULTIVATION AND TRADE IN INDIA

3.1 Indian trade scenario of raw botanicals

The annual demand of botanical raw drugs in India has been estimated to be 4-5 lakhs tonnes, out of which about 2.0-2.5 lakh tonnes is used by herbal industry, 1.0-1.5 lakh tonnes is used as rural household health care remedies and about 1.0 lakh tonnes is exported (Ved and Goraya, 2008). The annual trade value of these herbals ranges from 3-4 thousand crores. This data do not include demand of popular spices and fruits that are also used as raw herbal materials in health care drugs preparation. Out of 960 medicinal plant species in major trade, 178 species are consumed by more than 200 large and small registered herbal industries in volumes exceeding 100-500 tonnes per year. *Emblica officinalis, Terminalia*

chebula, T. bellerica, Sida rhombifolia, Withania somnifera, Tinospora cordifolia, Ocimum tenuiflorum, Eclipta prostrata, Andrographis paniculata and Asparagus racemosus occupy the top ten positions in this priority list. Thanks to National Medicinal Plants Board (NMPB, New Delhi) initiatives, several funding assistance schemes to encourage organized cultivation and processing of these in-demand botanicals are in operation in the country since last ten years. Similar incentives must be created for aromatic crops also. NMPB is presently supporting medicinal plants cultivation in nearly 2-3 lakhs hectares area, about 50,000 ha of which is under contractual farming. The Board is also supporting programs on resource augmentation, *in-situ* and *ex-situ* conservation, establishment of herbal gardens and nursery cultivation of medicinal plants in about 72,000 ha in the forest areas. Various funding schemes are in operation to support these initiatives, particularly the ones that are focused on species that are (i) highly endangered but are in high demand by AYUSH industry; (ii) species whose sources of natural supply are declining and; species for export demands. Special provisions are also being devised to fund infrastructure building initiatives for construction of drying sheds and storage godowns, primary processing and extraction plants, marketing collection centres, organic and Good Agricultural Practice certification labs, seed / germplasm centres and skill development.

3.2 Current S and T Leads and Know-hows

R&D work carried out on MACs cultivation and processing technologies in several National institutions of CSIR and ICAR systems like CSIR-CIMAP (Lucknow), CSIR-IIIM (Jammu & Kashmir), CSIR-IHBT (Palampur), CSIR-NEIST (Jorhat), ICAR-DMAPR (Anand) & MSME-FFDC (Kannuaj) during last 25-30 years has generated a wealth of useful data and experimental leads. Similar knowledge generation initiatives have also been started by several State Agricultural Universities and other governmental and non-governmental agencies such as NMPB, Spices Board of India, TIFAC, MSSRF, FRLHT and IHS. Unfortunately, the information thus generated has not been properly aligned and data-based for required harmonization and centralized retrieval for validation and application. Therefore, there is an urgent need to properly catalogue this accrued information base / leads to avoid overlaps and duplication of efforts and to help the farmers in deciding which crop and variety to grow in a given agro-climatic environment. Institutions like ICAR-DMAPR, CSIR-CIMAP and CSIR-IIIM may take the lead in this endeavor. Special funding mechanisms to support this national priority must be worked out with ICAR, DST, DBT, NMPB etc. There is also a need to create a state-wise national database of farmers and marketing agencies and review this data-base from time to time. Leads established by CSIR-CIMAP in generating a MACs farmers data-base may be emulated by other agencies.

3.3 Agro-Economic Potential of MACs Cultivation

The road to sensitize and motivate the farmers to take up organized commercial cultivation of medicinal and aromatic crops in the country can only be built if appropriate answers to the following basic questions are available ~ Which crop to grow? How to grow? Where and when to grow? Who will provide the quality planting materials for cultivation? Who will purchase the cultivated material and at what price? Who will accredit the quality of the produce? What will be the economic returns from cultivation of different MACs? Thanks to the efforts of many R&D institutions in the country, answers to many of these trust-building queries are now available for a few priority MACs Table 1.

Table 1. Present cultivation scenario and economics of some priority MACs in India (Source: www.cimap.res.in)

a) Mentha arvensis (Menthol mint)

Area under cultivation	Scale of annual production	Employment generation potential	Livelihood for	Genetically improved varieties available for cultivation
>2,50,000 ha	25,000 t	>4 crore man days/year	>5 lakh farmers families	CIM-Kosi, CIM-Himalaya, CIM-Saksham, CIM-Sambhav, CIM-Kushal; CIM-Saryu, CIM-Kranti, CIM-Gomti, CIM-Kalka

Agro-economics/ha

Single Harvest:

- Herbage Yield : 300 q.
- Oil yield : 125-150 kg.
- Gross return : Rs. 1,20,000/- (@Rs. 950/Kg oil)
- Cost of cultivation : Rs. 35,000-40,000/-
- Net Profit : Rs. 80,000/-

Two Harvest :

- Oil Yield : 225-250 Kg.
- Cost of cultivation : Rs. 55,000-60,000/-
- Gross return : Rs. 2,15,750/-
- Net Return : Rs. 1,50,000/-

*India is the largest producer and exporter of menthol mint oil in the world today

b) Plantago ovata (Isabgol):

Area under cultivation (ha)	Productivity (Kg/ha)	Total production (tons)	Improved varieties
Rajasthan - 184566 Gujarat - 81000 M.P - 2500	596 1519 1800-1900	109941 123030 4500	GI-1, GI-2, GI-3, Jawahar Isabgol-4 and Haryana Isabgol-5, Vallabh Isabgol-1, Niharika, Nimisha, Mayuri
Isabgol ranked first in total export of medicinal plants from India (130-160 million US$ during 2013-15). Annual growth rate of export is about 15%. Domestic market demand is > 90,000 tonnes. India dominates the world market by 80% share in production and global trade.			

c) Cassia angustifolia (Senna):

Area under cultivation (ha)	Productivity (Kg/ha)	Total production (tons)	Improved varieties
Gujarat - 4872 Tamil Nadu - 6100	1650 1435	8039 8753	CIM-Sona, ALFT-2, KKM, GAS-1
India is one of the largest producer and exporter of Senna leaf and pods in global herbal trade and earn Rs 160-200 crores of rupees annually.			

d) Mentha piperita (Pipermint):

Genetically improved varieties available for cultivation		
CIM-Kukrail, CIM- Indus, CIM-Madhuras, CIM-Tushar, CIM-Pranjal, CIM-Patra		
Agro-economics/ha		
Oil yield	:	80-100 kg
Market price	:	Rs. 1500/-
Gross return	:	Rs. 1,20,000
Cost of cultivation	:	Rs. 40,000
Net return	:	Rs. 80,000

e) Artemisia annua (The anti-malarial herb):

Genetically improved varieties available for cultivation		
CIM-Arogya, CIM-Jeevanrakshak		
Area under cultivation	:	>4000-4500 acres in Uttar Pradesh, Uttarakhand, Gujarat, MP and Bihar
Livelihood	:	> 3000 farmers under contractual farming with industry in PPP mode
Yield potential	:	30-35q dry leaves (4 months crop)
Price of dry leaves	:	Rs. 3400/q (Rs. 34/kg)

Agro-economics/ha	
Average yield	: 25-30qtls.
Gross return	: Rs 85,000/-
Cost of cultivation	: Rs. 25,000/-
Net profit	: Rs. 60,000/-

f) Withania somnifera (*Ashwagandha*):

Genetically improved varieties available for cultivation	
CIM-Poshita, CSIR-NIMITLI-118; Raj Vijay Aswagandh-100, Jawahar Aswagandha – 134, Nagori Suitable for rain-fed drought prone areas	
Area under cultivation	: Rajasthan – 2275 ha; M.P. – 13000 ha; A.P. 4000 h; U.P. – 100 ha
Total root production	: Rajasthan – 1800 t; M.P. – 8450 t; A.P. – 18000 t; U.P. – 60-80 t;
Livelihood for	: >6000 poor and small farmers

Agro-economics/ha	
Dry root Yield	: 6-8 q
Gross return	: Rs. 1,00,000 – 1,10,000/-
Cost of cultivation	: Rs. 35,000-40,000/-
Net Profit	: Rs. 60,000/-

g) Andrographis paniculata (Kalmegh/king of bitters):

Genetically improved varieties available for cultivation
CIM-Megha; Anand Kalmegh-1 (ideally suited for cultivation under shed in fruit orchards and forest cover; 4-month crop)

Agro-economics/ha	
Dry herb yield	: 30-35g
Market price	: Rs 30-35/Kg
Gross return	: Rs 90,000
Cost of cultivation	: Rs 35,000
Net return	: Rs 55,000

h) Asparagus racemosus (Shatawar):

Genetically improved varieties available for cultivation	
CIM-Shakti suitable for cultivation under shade	
Agro-economics/ha	
Dry herb yield	: 50-60q
Market price	: Rs 125-150/Kg
Gross return	: Rs 6,25,000
Cost of cultivation	: Rs 2,00,000
Net return	: Rs 4,25,000

i) Rauvolfia serpentina (Sarpgandha):

Genetically improved varieties available for cultivation	
CIM-Sheel; RI-1 suitable for cultivation under shade in fruit orchard (18-20 months crop)	
Agro-economics/ha	
Dry herb yield	: 15-20q
Market price	: Rs 200-250/Kg
Gross return	: Rs 3,00,000
Cost of cultivation	: Rs 1,10,000
Net return	: Rs 1,90,000

j) Aloe vera (Ghrit Kumari)

Genetically improved varieties available for cultivation	
CIM-Sheetal suitable for cultivation under dry rain-fed areas	
Agro-economics/ha	
Succulent leaf yield	: 500q
Market price	: Rs 500-250/q
Gross return	: Rs 2,50,000
Cost of cultivation	: Rs 1,10,000
Net return	: Rs 1,40,000

k) Vetiveria zizanioides (Khus):

Genetically improved varieties available for cultivation	
KS-1, Kesari, Dharni, Gulabi, CIM-Vriddhi, CIM-15, CIM-22, CIM - Khusimolika suitable for cultivation under drought stress, water logging, saline and high pH soils (10-18 months crop)	
Agro-economics/ha	
Dry root yield	: 20-25q
Essential oil yield	: 22-25 Kg
Market price of oil	: Rs 14000/Kg
Gross return	: Rs 3,08,000
Cost of cultivation	: Rs 1,00,000
Net return	: Rs 2,00,000

l) Ocimum basilicum (Indian basil):

Genetically improved varieties available for cultivation	
CIM-Saumya suitable for cultivation under rain-fed condition (2-3 month crop)	
Agro-economics/ha	
Herb yield	: 200-250q
Essential oil yield	: 100-120 Kg
Market price of oil	: Rs 600-700/Kg
Gross return	: Rs 60,000-70,000
Cost of cultivation	: Rs 25,000
Net return	: Rs 40,000

m) Pelargonium graveolens (Geranium)

Genetically improved varieties available for cultivation	
CIM-Pawan suitable for cultivation under sub-temperate and northern plains (3-4 month crop)	
AAgro-economics/ha	
Essential oil yield	: 25-30 Kg
Market price of oil	: Rs 8000/Kg
Gross return	: Rs 2,00,000
Cost of cultivation	: Rs 60,000
Net return	: Rs 1,40,000

n) Rosa damascena (Bulgarian rose):

Genetically improved varieties available for cultivation	
CIM-Noorjehan and CIM-Rani Saheba, CIM-Noorjahan suitable for cultivation under sub-tropical environments (Production stats after 3 years and continued for 10-15 years)	
Agro-economics/ha	
Essential oil yield	: 750-800g
Market price of oil	: Rs 8,00,000/Kg
Gross return	: Rs 5,00,000
Cost of cultivation	: Rs 50,000
Net return	: Rs 4,50,0000

o) Cymbopogon flexuosus (Lemongrass):

Genetically improved varieties available for cultivation	
CIM-Krishna, CIM-Cauvery, CIM-Chirharit, CIM-Suvarna; NLG-84, RRL-16, Praman, Pragati, Nima, CKP-25 suitable for cultivation in waste lands and water-deficient soils (Commercial production stats after 3-6 months and continued for 5-8 years with quarterly harvests)	
Agro-economics/ha	
Essential oil yield	: 200-250 Kg
Market price of oil	: Rs 850-900/Kg
Gross return	: Rs 1,80,000
Cost of cultivation	: Rs 60,000
Net return	: Rs 1,20,000

p) Cymbopogon martinii (Palmarosa):

Genetically improved varieties available for cultivation	
PRC-1, CIM-Tripta, CIM-Trishna, CIM-Harsh; RH-49 and CI-80-68 suitable for cultivation in irrigated and rain-fed conditions	
Agro-economics/ha	
Essential oil yield	: 120-150 Kg
Market price of oil	: Rs 1400-1500/Kg
Gross return	: Rs 1,70,000
Cost of cultivation	: Rs 60,000
Net return	: Rs 1,10,000

3.4 Location specific MACs-based solo or inter-cropping models for piloting

In this regard the Information generated by CSIR-CIMAP and ICAR-DMAPR on integration of MACs in agro-forestry and agri-horticultural systems is encouraging. Initial test results are promising in terms of land use efficiency (LUE), area time equivalency ratio (ATER) and efficient water, nutrient and pesticides usage that ultimately add to improved per unit returns for the growers. The advantage of MACs is that most of them require low-inputs, and can withstand stresses of salinity, alkalinity, drought, extreme temperatures, heavy metal toxicities, pest infestations and, hence can be very good candidates for the utilization of *hitherto* under-utilized/waste lands. They may also prove good alternatives for phyto-remediation and soil reclamation/rejuvenation efforts besides their potential of efficient carbon sequestration. Since useful secondary metabolites present in MAPs generally make them unpalatable to animals, pests and microbes, they can also be inter-cropped with food crops as protection shields. Tables 2 and 3 enumerate lists of MACs that may initially serve for piloting their testing and commercial cultivation in specific soil conditions or agro-climatic zones. The successful pilots can then be up-scaled with industrial linkages to provide organized clusters of MACs business / enterprises in the country. In the Himalayan zones, in particular, where land and water available for cultivation are the serious constraints, required acreage for production of each of the candidate MACs must be carefully evaluated to meet their industrial demand. Local R&D institutes like CSIR-IHBT, state government and village panchayats in consultation with MACs traders and industry must coordinate their efforts. Cropping system models ideally suited for sub-optimally utilized temperate forest, horticulture plantations and degraded soils may be prioritized in this exercise to take maximum advantage of multistory canopy cover of trees, shrubs and herbs outlined in Table 2. Integration of economical MACs like *Carthamus tinctures, Silybum marianum, Ocimum kilimandscharicum, O. gratissimum, Tagetes* spp.*, Mentha* spp. and *Cymbopogon* spp. with other species as intercrops might be a good alternative to address the menace of monkeys, wild animals, stray cattle and birds in the hilly zones.

Table 2. Prospective MACs suitable for piloting commercial cultivation in different agro-climatic regions

Agro-climatic zones	Prospective MACs
Western Himalayan region	*Valeriana jatamansi, Picrorrhiza kurroa, Swertia spp, Rosa damascena, Lavendula angustifolia, Salvia sclarea, Pelargonium graveolens, Artemisia annuaZanthoxylum alatum, Terminalia bellericais*; *Phyllanthus emblica; Tinospora cordifolia; Hedychium spicatum, Curcuma longa, Zingiber officinale* and *Angelica glauca*
Eastern Himalayan region	*Picrorrhiza kurroa, Pogostemon patchouli (cablin), Cymbopogon winterianus, C. flexuosus; Gingko biloba*, *Rosa damascena, Amomum subulatum* (Large cardamom), *Cinnamomum tamala* (Tejpatra), *Abies webbiana*, *Eucalyptus citriodora, E. tereticornis; Origanum vulgare*, *Vanilla planifolia*

Lower Gangetic plains	*Rauvolfia serpentina, Asparagus racemosus, Bacopa monnieri, Mentha arvensis, Ocimum basilicum, O. sanctum, Vetiveria zizanioides, Psoralea corylifolia*
Mid Gangetic plains	*Rauvolfia serpentina, Andrographis paniculata, Ocimum spp, Withania somnifera, Mentha spp.; Cymbopogon spp, Vetiveria zizanioides*
Upper Gangetic plains	*Glycyrrhiza glabra, Rauvolfia serpentina, Andrographis paniculata, Ocimum spp, Mentha arvensis; Mentha spp.; Cymbopogon spp, Vetiveria zizanioides*
Trans Gangetic plains	*Senna alexandrina (Cassia senna), Rauvolfia serpentina, Andrographis paniculata, Ocimum spp, Mentha arvensis; Mentha spp., Cymbopogon spp, Vetiveria zizanioides*
Eastern plateau & hill regions	*Rauvolfia serpentina, Andrographis paniculata, Withania somnifera, Rosa damascena, Mentha arvensis, Cymbopogon spp, Ocimum spp, Vetiveria zizanioides*
Central plateau & hill regions	*Rauvolfia serpentina, Senna alexandrina (Cassia senna), Commiphora wightii, Cymbopogon spp*
Western plateau & hill regions	*Senna alexandrina (Cassia senna), Andrographis paniculata, Glycyrrhiza glabra, Plantago psyllium (ovata), Withania somnifera, Commiphora wightii, Cymbopogon martinii*
Southern plateau & hill regions	*Senna alexandrina (Cassia senna), Andrographis paniculata, Commiphora wightii, Withania somnifera, Cymbopogon flexuosus; Gloriosa superba, Vetiveria zizanioides*
East coast plain & hill regions	*Rauvolfia serpentina, Cymbopogon spp, Pogostemon patchouli (cablin)*
West coast plains & hill regions	*Senna alexandrina (Cassia senna), Andrographis paniculata, Glycyrrhiza glabra, Plantago psyllium (ovata), Withania somnifera, Commiphora wightii, Cymbopogon spp*
Gujarat plains & hill regions	*Plantago psyllium (ovata), Ocimum spp., Rauvolfia serpentina,Rosa damascena, Vetiveria zizanioides*
Western dry zone	*Plantago psyllium (ovata), Senna alexandrina (Cassia senna), Andrographis paniculata, Commiphora wightii, Withania somnifera,Cymbopogon martini, C, flexuous, Ocimum spp, Vetiveria zizanioides*
The island regions	*Rauvolfia serpentina, Pogostemon patchouli (cablin), Ocimum basilicum, Vetiveria zizanioides, Cymbopogon species*

Table 3: Candidate MACs suitable for piloting commercial cultivation under various environmental stress and polluted soil conditions

Stress category	Intensity of stress	Recommended MACs
Moisture	Moderate	*Chamomilla recutita,* Jamarosa (*Cymbopogon* sp.), *Catharanthus roseus, Andrographis paniculata, Tagetes minuta, Artemisia annua*
	Severe	*Senna alexandrina (Cassia senna), Hyoscyamus muticus, Cymbopogon martinii, C. flexuosus, Plantago psyllium (ovate), Vetiveria zizanioides*

Salinity	Moderate	*Vetiveria zizanioides, Chamomilla recutita,* Jamarosa, *Catharanthus roseus, Mentha citrata, M. piperita, M. gracilis (cardiaca), Plantago psyllium (ovate)*
	Severe	*Hyoscyamus muticus, H. niger, Cymbopogon martinii, Artemisia annua, Cymbopogon flexuosus*
Sodicity	Moderate	*Tagetes minuta, T. patula, T. erecta, Plantago psyllium (ovate), Cymbopogon flexuosus*
	Severe	*Vetiveria zizanioides, Chamomilla recutita, Cymbopogon martinii, Ocimum basilicum, O. sanctum*
Polluted soils/ degraded	Gullied and/or Ravinous areas	*Cymbopogon flexuosus, Vetiveria zizanioides*
	Undulating upland	*Cymbopogon flexuosus, Vetiveria zizanioides*
	Surface water logged/ marshy area	*Vetiveria zizanioides, Acorus calamus, Bacopa monnieri*
	Salt affected soils	*Cymbopogon flexuosus, C. martinii, Vetiveria zizanioides*
	Forest, pasture, non forest soils	*Cymbopogon flexuosus, C. martinii, Vetiveria zizanioides, Catharanthus roseus*
	Mining industrial Wasteland	*Chamomilla recutita, Cymbopogon flexuosus, C. martinii, Vetiveria zizanioides, Catharanthus roseus*

ICAR-Central Soil Salinity Research Institute, Karnal has generated very useful data on yield responses of several released varieties of *Plantago psyllium (ovata)*, *Cymbopogon flexuosus, C. martinii, Vetiveria zizanioides, Glycyrrhiza glabra* under saline water irrigation (EC 4.0-10 ds m^{-1}) and cultivation in alkali soils with pH 8.4-9.9; ESP 18-59 Table 4.

Table 4. Productivity profile of some candidate MACs under salinity and alkaline stress (Source: ICAR-CSSRI, Karnal)

Grain yield (Kg/ha) of Plantago psyllium (ovata) varieties irrigated with saline water (EC 8.6 ds m^{-1})		**Fresh herb yield (t/ha) of Cymbopogon flexuosus varieties irrigated with saline water (EC upto 8 ds m^{-1})**		**Dry biomass yield (t/ha) of Cympogon martini, C. flexuosus and Vetiveria zizanioides in alkali soils**			
Variety	**Grain yield**	**Varieties**	**Herb yield**	**Soil pH (ESP)**	**Palmarosa**	**Lemongrass**	**Vetiver**
JI-4	1603	OD-58	28.3	8.4(18)	20.2 – 1st Yr	23.4 – 1st Yr	24.1 – 1st Yr
Sel-10	1532	RRL-16	27.6		43.1 – 2nd Yr	21.3 – 2nd Yr	30.8 – 2nd Yr
Niharika	1503	Praman	17.4	9.1(25)	16.5 – 1st Yr	15.8 – 1st Yr	32.4 – 1st Yr
HI-5	1448	Krishna	11.7		39.1 0 2nd Yr	19.9 – 2nd Yr	41.1 – 2nd Yr
GI-2	1436	OP-19	3.3	9.5(41)	15.6 – 1st Yr	10.4 – 1st Yr	31.3 – 1st Yr
GI-1	1401	Pragati	0.9		34.6 – 2nd Yr	12.4 – 2nd Yr	36.0 – 2nd Yr

HI-34	568	Nima	0.2	9.9(59)	7.4 – 1st Yr	7.2 – 1st yr	24.9 – 1st Yr
Local	1002	CKP-25	0.1		19.2 – 2nd Yr	8.1 – 2nd yr	37.1 – 2nd Yr
Mean	1312			The corresponding dry root biomass yield in case of vetiver varies between 1.6 to 1.1 t/ha under such alkali stress			

Yield (t/ha) of Glycyrrhiza glabra roots under different alkali stress conditions				
Root yield	**Soil pH (ESP) levels**			
	8.4 (26.0)	9.2 (35.0)	9.5 (40.5)	9.8 (59.7)
Harvest after 2 Yr	2.54	2.82	3.25	3.00
Harvest after 3 Yr	6.11	6.73	7.89	7.57

3.5 Prospective MACs for piloting inter-/mixed-cropping in existing agri-calender

Since cultivation of MACs on lands that are presently utilized for producing food crops is neither advisable nor justified, their proper integration into the existing cropping systems as complementary rather than supplementary systems is more desirable. Therefore, in addition to advancing R&D domains of genetic up gradation, varietal improvement and development of suitable agro-technologies for cultivation of industrially important MACs in different agro-climatic zones of the country, it is also necessary to generate data on potential inter- or mixed-cropping systems of medicinal and aromatic crops that have high industrial demand. Models based on MACs + food crops, MACs + MACs, MACs + horticultural and MACs + forest trees combinations should be developed to work out the economic returns from such efforts. The allelopathic influences of MACs on the productivity of agricultural crops in such mixed cropping scenarios would be another line of investigation that may yield remunerating savings for small farmers. Tables 5 and 6 suggest some of the possible season- and area-specific MACs-based inter- or mixed-cropping models that may be piloted in the country. Based on these models need-specific and area-specific remunerative systems can be developed through R&D. These new paradigms will not only provide extra returns to the farmers without disturbing the food production, but would also provide an attractive alternative to land and resource usage optimization. This integration process can be prioritized with those MACs that are in bulk demand by the industry, have preferably short duration life cycle to fit into relatively off-seasonal agro-calendar, have high environmental adaptability, with simple post-harvest primary processing requirements, better physiological and agronomic compatibility with the food crop(s). The perennial MACs may be exploited in agro-forestry and agro-horticulture set ups.

Table 5. Prospective MACs suitable for integration in prevailing agri-calendar

Integration with rainy season crops	Integration with winter season crops	Integration with summer season crops
Ocimum basilicum, O. sanctum, Andrographis paniculata, Senna alexandrina, Abelmoschus moschatus, Withania somnifera	*Withania somnifera*, *Papaver somniferum*, *Plantago psyllium (ovata), Chamomilla recutita, Aloe vera, Silybum marianum*	Mentha arvensis, Pelargonium spp., Aloe vera, Artemisia annua

Table 6. Some possible MACs-based inter-cropping models (Source: Kala et al. 2006; CSIR-CIMAP R&D leads)

Major cultivation domains	Candidate combinations	Major advantages
In forestry / agro-forestry / horti-cultural systems	Aonla + Lemongrass; Aonla + Palmarosa; Eucalyptus + Lemongrass; Eucalyptus + Citronella Mango + Patchouli; Poplar + Palmarosa; Arjun + Lemongrass; Poplar + Mentha; Eucalyptus + Artemisia; Guava + Lemongrass; Eucalyptus + Palmarosa	More carbon sequestration; enhanced microbial diversity in the soil; more income from underutilized land; early returns; ecosystem sustainability; safety to main crop from wild animals
Integration with rainy season crops	Citronella + (cowpea-fingermillet); Citronella + (greengram-fingermillet); Citronella + (greengram-groundnut); Citronella + (greengram-sorghum); Palmarosa + cowpea; Pigeonpea+Tulsi; Pigeonpea+Kalmegh; Pigeonpea+sarpgandha; Pigeonpea+mints for sucker production; Urd+Palmarosa; Urd+Vetiver; Moong+Vetiver; Moong+Lemongrass; Moong+Palmarosa; Maize+Tulsi; Maize+Kalmegh; Maize+Phyllanthus; Maize+Sarpgandha; Maize+Safed musali (Clorophytum borivilianum); Bajra+Tulsi; Bajra+Phyllanthus; Bajra+Sarpgandha; Bhindi+Tulsi; Bhindi+Kalmegh; Bhindi+Phyllanthus; Bhindi+Sarpgandha; Bhindi+Mints for suckers; Jowar+Tulsi; Jowar+Kalmegh; Jowar+Phyllanthus; Jowar+ Sarpgandha; Sugarcane+ bergamot mint; Sugarcane+ peppermint; Sugarcane+ spearmint	Assured and regular income from rainfed farming; Natural and cost effective weed management in rainy season;
Integration with winter season Crops	Wheat+ Mints; Gram+Lemongrass; Gram+Cetronella; Peas+Lemongrass; Peas+Citronella; Carrot+Tagetes minuta; Methi+Tagetes minuta; Onion+Tagetes minuta; Radish + Tagetes minuta; Garlic+Rose-scented geranium; Onion+Rose scented geranium; Rabi Maize + Peppermint / Begamot mint / Menthofuron rich Mint; Autumn planted Sugarcane + Peppermint / Begamot mint; Rauvolfia + Onion in rainy season followed by garlic in cold weather; Groundnut / black gram + Opium poppy/ Mint rotation; Potato- Mint - soyabean - paddy rotation; Rose scented geranium + cowpea or blackgram	Less competitive production in sub-tropical & irrigated plains; Optimal resource utilization; better land utilization for sustaining soil fertility

Integration with summer season crops	Sugarcane+Mints; Sugarcane+Rose scented geranium; Sugarcane+Senna; Sugarcane+Withania; Bhindi+Mints; Onion+Mints; Lobiya+Mints; Radish+Mints	Better resource utilization; protection from wild animals; employment generation in off season; better carbon sequestration
Integration of MAPs through overlapping cropping systems	Maize + Withania; Pearl millet + Withania; Bhindi + Withania; Pigeonpea+Withania; Pigeonpea+Mint; Wheat +Mints; (Pearl millet + Basil) + Withania; (Maize + Basil) + Withania; (Bhindi + Basil) + Withania; (Lemongrass + Basil) + Barley; (Lemongrass + Basil + Basil) + Barley; (Lemongrass + Basil) + Peas; (Lemongrass + Basil + Basil) + Peas; (Lemongrass + Basil) + Linseed; (Lemongrass + Basil + Basil) + Linseed; (Vetiver + Basil + Basil) + Barley; (Vetiver + Basil) + Peas; (Vetiver + Basil + Basil) + Peas; (Vetiver + Basil) + Linseed; (Vetiver + Basil + Basil) + Linseed; (Palmarosa + Basil + Basil) + Barley; (Palmarosa + Basil) + Peas; (Palmarosa + Basil) + Linseed; (Palmarosa + Basil + Basil) + Peas; Sorghum + Redgram + 2 : 1 Clusterbean / greengram - Geranium + greengram; Pearlmillet + clusterbean / greengram-Geranium+greengram; Sunflower + redgram + 2 : 1 clusterbean / greengram-geranium + greengram; Geranium + clusterbean / greengram	Opportunity for 200 to 400% cropping intensity is in rainfed areas; best use of residual soil moisture and nutrient especially phosphorus; additional employment generation

3.6 Linkages within the value chain for cultivation and marketing

Presently, there is a lack of proper value-chain mapping and analysis in MACs trade in the country. Inventorization / registration of MACs growers, seed / planting material providers, traders, processors, exporters, and service providers is far from adequate. Therefore, it was appropriate that NAAS in collaboration with R&D organizations, NMPB, Horticulture board industries, government departments examined and identified the gaps to prepare a policy frame work for all stakeholders of herbal cultivation, processing and marketing value-chain. The academy may also suggest some proactive measures for linking farmers with end-user industry, funding institutions and quality accreditation agencies to impart a cutting edge advantage to Indian herbal business for export. Since the primary concern of all small farmers is easy access and availability of proper outlets for selling their farm produce, appropriate marketing hubs for MACs must be established at strategic locations around major cultivation zones in the country. Some of the other incentives that may be taken up in this direction by the central and state governments may include: minimum support price for MAC farmers; establishment of centralized collection centres and storage facilities for the produce and market for trading; Installation of centralized primary processing / distillation units for farming clusters; formal mechanism for registration of MACs farmers to facilitate the inter-state movement of harvested materials and their primary processed produce; establishment of separate sale counters of MACs products in existing “Kisan Mandis: and; systems for providing proactive market information and forecasting on demand and price.

Provisions for on-line trading options and portals can also be worked out to ensure better cost returns to MACs farmers and entrepreneurs. The Ministry of AYUSH through its National Medicinal Plant Board may also coordinate with Ministry of Forest and National Biodiversity Conservation Authority and propose new guidelines to discourage the wild collections of MAPs from natural habitats. Mechanisms for more regulated licensing for restricted collection from natural habitat, fixing higher price for produce from such non-destructive and sustainable collection in order to encourage the end user industries to procure only cultivated MACs. Encouraging organic cultivation of MACs at reasonable price, organic certification, establishment of farmers' training centers like KVKs, encouraging cultivation by tribal communities in degraded forest lands through "vana sanrakshana samithies" etc. are some of the points that need policy direction and funding.

Since there exists a very thin line of demarcation between several traditional MACs and common Indian spices (almost all spices are valued for their medicinal / aromatic bioactive constituents), MACs business in the country and their exports can also be greatly channelized by establishing a close linkage with the activities and initiatives of Spices Board of India. It may be appropriate to recall that India is the largest producer, consumer and exporter of spices in the world accounting for 48% of global spices production and 43% of world spices trade. About 0.8-0.9 million tonnes of spices valued at US$ 2.0-2.5 billion were annually produced in India during last two years. Out of this total spices production, 89% is annually consumed in the domestic market while 11% is exported. During 2009 and 2015, India's spices market has grown with an annual growth rate of 8.8%. The country has exported about 893,920 tonnes of spices valued at US $ 2440.8 million (Rs. 14,900 crores). The United States of America, China, UK. Germany, Thailand, Vietnam, Malaysia, and Sri Lanka are the major importers of Indian spices (www.indianspices.com). This impressive business scenario has largely been the outcome of many innovative measures taken up by the Indian government. Notable among these initiatives are establishment of dedicated spices parks/villages in MP, Kerala, Tamil Nadu and A.P., chain of quality accreditation laboratories at major ports of export like Cochin, Mumbai, Delhi, Chennai, Tuticorin and Kolkata and post harvest processing clusters for value addition. Such interventions in the MACs sector must also be replicated to increase India's share in the global herbal business. MACs cultivation and trade in the country can also be benefited if provisions for e-auctions and e-bazars as available for spices can also be duplicated. Government on its part can also extend subsidy and support price for MACs farmers and traders as has been provided to spices and agricultural farmers.

Appropriate linkage of MACs farmers with end user industry, presently has many gaps in the value chain, those must be plugged for mutual benefits. Industry must open up in terms of projecting their requirement, while such projections have begun to appear in case of aroma

industry, the pharmaceutical companies are still not forthcoming in terms of their annual demands and desired quality attributes of the materials they wish to procure. Farmers always prefer to have assured buy-back arrangements with the industry to avoid situations of market saturation or surplus production that often put them at a disadvantageous position in the price bargain. Initiatives recently launched by a few health care companies, like building farmers network for sustainable cultivation, grading and processing of scientifically characterized medicinal herbs with Good Agricultural and Collection Practices (GACP) compliance, are welcome signs for such confidence building measures. Out of some nearly 950 herbs used in various formulations, Himalaya Drug Company has initiated contractual farming of certified crop varieties of 200 medicinal crops that are required in quantities ranging from 100-250 tonnes per year. This systematic amalgamation and hand-holding exercise between industry-farmers-academia by the Company has so far benefited >1800 farmers (particularly women workers) with 100% buy-back guarantee. Direct contact with the industry eliminates interventions from middlemen to farmers, farmers are happy to get a fair price for their produce, adding 30 to 40% in their annual income. Industry can also derive satisfaction through such linkages in terms of an uninterrupted and timely supply of their quality raw herbal materials at constant pricing for their business expansion and commitments.

Similarly, the demand, production and trading information on essential oils of major aromatic crops for flavors and fragrances, compiled by Essential Oil Association of India (EOAI), and Flavours and Fragrances Association of India (FFAI) can be taken as a base advisory. According to this database India ranks fourth after Brazil, China and Egypt in amount of essential oils annually produced in the world. Besides consumption in the domestic sectors, large quantity of essentials oils is also exported to USA, Japan and European Union States. This survey also suggests that nearly 300 different types of essential oils are globally traded, out of which 110 contribute to 95% of world consumption by fragrance and flavor industry. Out of these 300 essential oils, 10 major oils are classified as low price oils and account for 80% trade whereas 290 high-price oils are required in small quantity and contribute to 20% of business (Table 7). About 50% of the total essential oils production (ca. 1, 20, 000 tonnes) comes from the cultivated sources; rest comes either from wild plant sources or as by-products of a primary processing industry. Number of by-products are also produced during the distillation of crops such as hydrosols spent biomass, ash, biochar etc. Methods for the utilization of such by-products must be worked out for enhancing the farmer's income or reducing the cost of cultivation. Utilization of distilled biomass of aromatic crops for vermi-composting may constitute an important strategy in this direction. India can be a strategic player in this area.

Table 7. Global business scenario of essential oils in fragrance and flavor industry (Source : Essential Oil Association of India; Flavours and Fragrance Association of India)

Name of the oil	Annual global consumption (tons)	Major producing countries
Cornmint (menthol mint)	35000	India, Brazil, USA, Spain, Israel, Mediterranean countries
Peppermint	4000	USA, India, China
Citronella	3000	Srilanka, China, India, Java, Taiwan, South & Central America
Eucalyptus	5000	China, Spain, Portugal, Brazil, Australia, South Africa, India
Lemongrass	2200	China, India, West Indies, Central America, Africa.
Patchouli	900	Indonesia, India.
Vetiver	260	Indonesia, Haiti, China, India
Lavender	420	France, Bulgaria, Tasmania, China, India
Geranium	600	China, Reunion, Madagascar, Egypt, India
Nutmeg	180	Indonesia, India, West Indies
Ginger	120	India, Malaysia, Taiwan, Australia, Fiji
Sandalwood	100	India, Austrialia, Indonesia
Palmarosa	60	India, Seychelles, Pakistan, Comoro islands
Celery	50	France, India, Hollan, Hungary, China
Rose	20	Bulgaria, Turkey, France, Morocco, India
Jasmine absolute	15	China, India, Egypt, Morocco
Cumin	10	India, Egypt, Iran
Calamus	10	European union, India
Davana	3	India
Other minor oil produce: Cinnamon, Cardamom, Tagetes, Valerian, Agarwood, Celery, Tube rose absolute, Ambrette seed oil		Srilanka, India, Seychelles, Madagascar, Zimbabwe, South Africa, China, Guatemala, India, Thailand, Vietnam

4.0 RECOMMENDATIONS AND ACTION PLAN

Policy issues

- MACs cultivation may be positioned in synergy with Nation's food, nutrition, income and health security missions to aim for a New Normal domain.

- The MACs cultivation in India may be re-structured with adequate R&D back up for small farmers. The present day poor share of our country (<2.0%) in the global business of MACs must touch at least 10% mark in next ten years.
- Successful pilots involving MAPs cultivation, processing and marketing must be evolved, up-scaled and out-scaled. Successful contract-farming methodologies with buy-back assurance for small farmers need replication in different agro-climatic conditions.
- MACs with bulk industrial demands and wider climatic adaptability like Vetiver, Patchouli, Lavender, Ashwagandha etc. may be considered as good pilot candidate crops for acquiring global leadership position for India as achieved with Menthol mint production.
- Organic farming of MACs should be prioritized for crops that are either consumed as raw herbs in healthcare foods / supplements or have high export potential.
- Establishment of centralized collection centres and storage yards for crops produce, installation of centralized primary processing / distillation units for farming clusters at Panchayat level, formal registration of MACs farmers for facilitating free inter-state movement of their harvested materials and establishment of separate sale counters of MAPs products in existing Kisan Mandis must be explored on priority.
- The AYUSH Ministry in consultation with Ministry of Environment, Forest and Climate Change, National Biodiversity Conservation Authority must formulate a revised policy for prevention of wild collection of rare, endangered and threatened (RET)-listed medicinal herbs.
- A National Aromatic Plants Board on the existing lines of National Medicinal Plants Board may be set up in the country to specifically look into the R&D, cultivation, processing and business aspects of this sector.

Research and development issues

- High quality scientific interventions and back-up for popularizing MACs cultivation for higher land and water use efficiency on one hand, and improving the metabolic spectrum of bioactive substances they harbor should occupy prime attention. Funding agencies must devise special schemes to support such efforts. R&D institutions must join hands and create a separate corpus for giving R&D thrust to this National mission.
- Special nursery cultivation program may be augmented for ensuring the supply of validated authentic and elite seed/planting materials/varieties developed by different research laboratories for their commercial cultivation.
- Existing crop-wise R&D data and know-how on breeding and agrotechnology package of practices for the cultivation, harvesting and post-harvest processing together with the present industrial demands needs to be harmonized, compiled and databased to support MACs sector.

- For encouraging on-line trading options, appropriate IT portals need to be created for MACs farmers and entrepreneurs.
- There is an urgent need to set up a chain of quality accreditation and certification agencies for MACs business in the country. Efforts must be made to have one uniform standard specification for quality of a particular crop across the nation.
- Initiatives towards domestication, varietal improvement and planned cultivation of those MACs that are presently obtained exclusively from the wild, like *Centella asiatica*, *Picrorrhiza kurroa*, *Podophyllum hexandrum, Commiphora wightii*, *Piper longum, Bacopa monnieri, Adhatoda vasica, Plumbago zeylanica, Desmodium gangeticum, Oroxylum indicum, Andrographis paniculata, Catharanthus roseus, Rauvolfia serpentina, Acorus calamus, Tinospora corylifolia etc* must be taken- up on priority by R&D institutions.
- Farmers must be encouraged and trained in all aspects of organic farming to obtain requisite certification from associations that do the monitoring of such cultivation to generate extra income.
- Ecological services provided by MACs such as carbon sequestration, soil erosion control, phytoremediation, reclamation of problem soils, low pesticides and other agro-chemicals load in the environment etc. have to be researched and quantified.
- Inventorization and patenting of local health formulations, processes and practices/ traditions to protect local traditional knowledge from biopiracy should be a priority. Scientific authentication of Indian Ayurvedic drugs to internationalise their usage would increase the demand and create new market for Indian herbs.

Human resource development

- Course curricula on MACs in agricultural universities need to be revisited and strengthened for raising a critical mass of trained manpower.
- Extensive awareness training programs for on-farm demonstration on MACs must be organized for popularizing their planned cultivation in different agro-climatic zones of the country. Interactive e-portals / SMS service provisions for providing real time advice to farmers must be set up for better communication between the growers, scientists and industry.
- Appropriate farm bulletins and short video films on the Good Agricultural Practices (GAP), and Good Manufacturing Practices (GMP) of recommended MAPs cultivation models, need to be prepared in Hindi, English and other regional languages for wider publicity and adoption.

- ❖ Frequently organizing kisan melas and farmer-trader meetings in different states for exchange of ideas and products among stakeholders. Establishment of training centres in line with KVKs also needs to be examined.

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