Expert Consultation on Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region

Bangkok, Thailand
2-3 December, 2013

Proceedings

Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)
Food and Agriculture Organization of the United Nations - Regional Office for Asia and the Pacific (FAO RAP)

Expert Consultation on Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region

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PROCEEDINGS

Editors

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S.P. Ghosh and S.K. Pareek

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The Organizers

APAARI (Asia-Pacific Association of Agricultural Research Institutions) is a regional association that aims to promote the development of National Agricultural Research Systems (NARS) in the Asia-Pacific region through inter-regional and inter-institutional cooperation. The overall objectives of the Association are to foster the development of agricultural research in the Asia-Pacific region so as to promote the exchange of scientific and technical information, encourage collaborative research, promote human resource development, build up organizational and management capabilities of member institutions and strengthen cross-linkages and networking among diverse stakeholders. To meet these needs, the Association: i) convenes General Assembly once in two years, holds regular Executive Committee meetings yearly and organizes consultations, workshops, trainings, etc., ii) collects, collates and disseminates research findings, iii) maintains links with other fora in the region and outside through meetings, participation and information exchange, and iv) promotes need based collaboration in research projects among member institutions, analyzing priorities and focusing on regional agricultural development. For details, please visit: *www.apaari.org*

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Foreword

Asia and the Pacific region is very rich in its diversity of medicinal and aromatic plants (MAP). Any threat to these valuable resources will not only jeopardize the health of millions of people in the region, but will also affect the livelihoods of resource poor farmers and communities that depend on them. Therefore, more focus should be placed on research, development and marketing of medicinal and aromatic plants by countries in Asia and the Pacific. It is well known that over 80 per cent of the world's population depend largely on traditional medicines derived from plants for their healthcare. In some developed countries, medicinal and aromatic plants have moved from essentially unknown, minor agricultural plants to crops that many farmers consider economically remunerative, safe and beneficial to society. Medicinal and aromatic plants deserve urgent attention to ensure their conservation, evaluation, genetic enhancement and scientific cultivation by the farming communities in the region.

Today, many valuable medicinal and aromatic plants are available in Asia and the Pacific. People living in the region can benefit from these plants if they adopt scientific methods to increase production, link producers to markets and enable value to be created through the supply chain. It is also extremely important to conserve the genetic resources of medicinal and aromatic plants in order to save them from extinction, since they are otherwise exposed to overexploitation and the negative consequences of climate change. The growing demand for medicinal and aromatic plants makes them remunerative alternative crops for smallholder farmers. However, more research is needed on propagation methods, harvesting and processing techniques, germplasm collection, genetic improvement, quality control and marketing.

In view of the above concerns, a Regional Expert Consultation on Promotion of Medicinal and Aromatic Plants in Asia and the Pacific Region was organized jointly by the Food and Agriculture Organization of the United Nations (FAO) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI) from 2-3 December 2013 in Bangkok, Thailand. The consultation was attended by 38 experts from 14 countries including representatives from the FAO Regional Office for Asia and the Pacific and APAARI. The expert consultation provided a neutral platform to share knowledge and experiences, to discuss a future Road Map to promote medicinal and aromatic plants, and to hold in-depth discussions and assess national and regional priorities. It also enabled participants to address the emerging issues and challenges for making this vital MAP sector more vibrant, demand driven and market oriented.

These proceedings provide the main recommendations of the expert consultation as well as extended summaries of lead papers and country reports. It is hoped that the recommendations that emerged from the consultation will draw the attention of policy-makers, administrators, researchers, industry, farmers and other stakeholders to the need for enhancing research, development and extension efforts in promoting medicinal and aromatic plants in the Asia-Pacific region.

Hiroyuki Konuma
FAO Assistant Director General and
Regional Representative for Asia and the Pacific

Raj Paroda
Executive Secretary
APAARI

Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADG	Assistant Director General
AEC	ASEAN Economic Community
AEZ	Agro-Ecological Zone
AICRP	All India Coordinated Research Project
AMS	Agriculture Marketing Services
AOAC	Association of the Agricultural Chemists
APAARI	Asia-Pacific Association of Agricultural Research Institutions
AR4D	Agricultural Research for Development
ATSC	Australia Tree Seed Centre
AYUSH	Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy
BAP	Biodiversity Action Plan
BARC	Baluchistan Agricultural Research Centre
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BCSIR	Bangladesh Council of Scientific and Industrial Research
BDT	Bangladeshi Taka
BFRI	Bangladesh Forest Research Institute
BOT	Balance of Trade
BPI	Bureau of Plant Industry
BSI	Botanical Survey of India
CA	College of Agriculture
CAM	Complementary and Alternative Medicine
CAMP	Conservation Assessment and Management Plan
CBD	Convention on Biological Diversity

CDRI	Central Drug Research Institute
CHIPI	Chamber of Herbal Industries of the Philippines Inc.
CIDS	Cholistan Institute of Desert Studies
CIMAP	Central Institute of Medicinal and Aromatic Plants
CISR	Council of Scientific and Industrial Research
CITES	Convention of International Trade in Endangered Species
CITES	Convention on International Trade in Endangered Species
CSC	Crop Science Cluster
CSIR	Council of Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organization
DAMC	Department of Agricultural Marketing and Cooperatives
DAR	Department of Agricultural Research
DBT	Department of Biotechnology
DDG	Deputy Director General
DENR	Department of Environment and Natural Resources
DMAPR	Directorate of Medicinal and Aromatic Plants Research
DOA	Department of Agriculture
DOFPS	Department of Forest and Park Services
DOH	Department of Health
DOST	Department of Science and Technology
DUS	Distinctiveness, Uniformity and Stability
ECER	East Coast Economic Region
EEC	European Economic Community
ERDB	Environment Research and Development Bureau
ETP	Economic Transformation Program
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FD	Forest Department
FDA	Food and Drug Administration

FELDA	Federal Land Development Authority
FFM	Flavor and Fragrance Materials
FRI	Forest Research Institute
FRIM	Forest Research Institute of Malaysia
FRLHT	Foundation for Revitalization of Local Health Traditions
GACP	Good Agricultural and Collection Practices
GACP	Guidelines on Agricultural and Collection Practices
GAP	Good Agricultural Practices
GBPIHED	G.B. Pant Institute of Himalayan Environment and Development
GCP	Good Clinical Practices
GCP	Good Collection Practices
GFCP	Good Field Collection Practices
GLP	Good Laboratory Practices
GMP	Good Manufacturing Practices
GNI	Gross National Income
GoB	Government of Bangladesh
GOF	Government of Nepal
GSP	Good Storage Practices
HAPPRC	High Altitude Plant Physiology Research Center
HDO	Herbal Development Office
HPPCL	Herb Production and Processing Co. Ltd.
IC	International Cooperation
ICAR	Indian Council of Agricultural Research
ICFR	Indian Council of Forestry Research
ICIMOD	International Center for Integrated Mountain Development
IFAD	International Fund for Agriculture Development
IHDP	Integrated Horticulture Development Project
IMOD	Inclusive Market Oriented Development
IPB	Institute of Plant Breeding

IPR	Intellectual Property Right
ISHS	International Society for Horticultural Science
ISM	Indian System of Medicine
ISMH	Indian Systems of Medicine and Homoeopathy
ITK	Indigenous Traditional Knowledge
ITMS	Institute for Traditional Medicine Services
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
LBES	Los Baños Experiment Station
MAP	Medicinal and Aromatic Plants
MAPPA	Medicinal and Aromatic Plants Program in Asia
MARC	Mountain Agricultural Research Center
MARDI	Malaysian Agriculture Research and Development Institute
MFSC	Ministry of Forest and Soil Conservation
MoEF	Ministry of Environment and Forests
MPCA	Medicinal Plant Conservation Area
MPCP	Medicinal Plant Conservation Parks
MPCS	Medicinal Plant Conservation Sites
MPDA	Medicinal Plants Development Areas
MPDS	Medicinal Plant Development Sites
MPFI	Moringaling Philippines Foundation Inc.
MPHP-BPC	Medicinal Plants and Herbal Products Business Promotion Council
NARC	National Agricultural Research Center
NARC	Nepal Agricultural Research Council
NARS	National Agricultural Research System
NARTS	Neelibar Agricultural Research & Training Station
NBC	National Biodiversity Center
NBPGR	National Bureau of Plant Genetic Resources

NCE	New Chemical Entities
NDoH	National Department of Health
NIBI	National Institute of Biomedical Innovation
NIHHS	National Institute of Horticultural & Herbal Science
NIRPROMP	National Integrated Research Program on Medicinal Plants
NKEA	National Key Economic Areas
NMPB	National Medicinal Plants Board
NPGRL	National Plant Genetic Resources Laboratory
NPHC	National Post Harvest Center
NPPC	National Plant Protection Center
NTFP	Non-Timber Forest Produce
NWFP	Non-Wood Forest Produce
OTC	Over The Counter
PARC	Baluchistan Agricultural Research Center
PARC	Pakistan Agricultural research Council
PCHRD	Philippine Council for Health Research and Development
PFI	Pakistan Forest Institute
PGR	Plant Genetic Resources
PGRC	Plant Genetic Resources Center
PGRI	Plant Genetic Resources Institute
PITAHC	Philippine Institute for Traditional and Alternative Health Care
PNG	Papua New Guinea
PPP	Public-Private Partnership
PPPPP	Pro Poor Public Private Partnership
PPVFRA	Protection of Plant Varieties and Farmers' Rights Authority
PTPMA	Pakistan Tibbi Pharmaceutical Manufacturing Association
PTPMA	Pakistan Tibbia Pharmaceutical Manufacturing Association
R&D	Research & Development
R4AD	Research for Agricultural Development

RAP	Regional Office for Asia and the Pacific
RC	Regional Center
RCSC	Royal Civil Service Commission
RDA	Rural Development Administration
RET	Rare, Endangered and Threatened
RNRRDC	Renewable Natural Resources Research and Development Center
SAU	State Agricultural University
SDC	Swiss Agency for Development and Cooperation
SEDF	South Asia Enterprise Development Facility
SHG	Self Help Group
SITC	Standard International Trade Classification
SMAP	Spices, Medicinal and Aromatic Plants
SME	Small and Medium Enterprises
SRC	Spices Research Center
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAHC	Traditional and Alternative Healthcare
TAMA	Traditional and Alternative Medicine Act
TCM	Traditional Chinese Medicine
TIM	Traditional Indian Medicine
TK	Traditional Knowledge
TMS	Traditional Medicinal System
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
UPLB	University of the Philippines Los Baños
USD	United States Dollar
VFRDC	Vegetables and Fruits Research and Development Center
WCO	World Commerce Organization
WHO	World Health Organization
WWF	World Wildlife Fund

Executive Summary

The Asia region has a long tradition of use on herbal medicines and has very rich diversity of medicinal and aromatic plants (MAP). Out of about 8,000 species having ethnobotanical properties, 2,500 MAP species are primarily used in different traditional medicinal systems and only about 250 MAP species are traded in large volumes. The world trade in botanicals is US $ 32.702 billion of which Asia accounts for US $ 14.505 billion (44.35%). This vast resource is the mainstay of raw material supply to industries for drug formulations, nutritional applications, food flavoring, perfumery, cosmetics, toiletries, etc. The increasing demand for herbal products has forced the overexploitation and unscientific collection of natural populations of medicinal and aromatic plants from the forest rendering several species to vulnerable state and most Asia -Pacific countries are experiencing the loss of diversity. Any threat to these valuable resources will not only jeopardize the health safety of millions of people but also the growing global market of medicinal and aromatic plants and also the livelihood of resource poor farmers and communities that depend on them. Therefore, this sector deserves a renewed thrust and priority attention by the countries in the Asia-Pacific for adequate research, development and marketing activities in order to ensure their better utilization and conservation. It is also extremely important to conserve the genetic resources of MAP species in order to save them from extinction, overexploitation and negative consequences of climate change. The significance of MAP species has risen in recent years due to substantial change in the life style and negative impacts of modern chemical based products and increasing requirements on quality, safety, and efficiency of medicinal and aromatic plant products.

In view of these facts, Food and Agriculture Organization of United Nations (FAO) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI) jointly organized a "Regional Expert Consultation on Promotion of Medicinal and Aromatic Plants in Asia and the Pacific Region" at Bangkok, Thailand on 2-3 December, 2013. In all, 38 delegates from 14 countries, namely, Bangladesh, Bhutan, India, Japan, Malaysia, Myanmar, Nepal, Papua New Guinea, Pakistan, the Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam participated in the expert consultation. In addition, representatives and experts from medicinal plants industry, the Pacific region, FAO RAP, and APAARI, also participated.

The objectives of the consultation were to assess the current status of MAP species in Asia and the Pacific region and identify future needs, share knowledge and technologies, identify relevant policy options for strengthening conservation and sustainable development of these resources and strengthen regional collaboration through networking for promotion and sustainable use of medicinal and aromatic plants. Through this consultation, it was aimed to consolidate the available information on production, R&D efforts and policy issues on MAP in the Asia-Pacific region.

The two day consultation was structured into Inaugural Session, three Technical Sessions, three Working Group Discussions and a Plenary Session. In the Inaugural Session, two lead papers on MAP species covering the areas of promotion of MAP and marketing aspects of MAP in the Asia-Pacific Region were presented. In two Technical Sessions, 14 country reports were

presented and discussed. The key highlights of the country reports indicated that the MAP species are often called as non-timber forest produce (NTFP). It was strongly felt that now these species must be designated as future crops for human needs. The MAP species are a large group, having diversified growing habits and habitats and require prioritization of species for cultivation, value addition and conservation efforts. The investment in R&D has to be enhanced substantially and more institutions need to be created. There is a need to develop effective and demand driven R&D program on plant genetic resource (PGR) management with special attention on rare, endangered and threatened (RET) species, crop improvement, crop production, post-harvest management and developing good agricultural practices (GAP) and well organized organic farming. The quality aspects are the most important and should be taken care from raw material stage to finished product. An effective and easy mechanism for certification of organically produced raw material with defined quality be developed in each country for producers and users of MAP species. The MAP sector has several stakeholders and requires networking of all such players. An effective partnership between private sector and R&D organizations is essential. The needed information on collection of raw material from forest, production from cultivation, value addition and trade is lacking in all the countries. Therefore, a mechanism needs to be developed in each country to document all such information authentically. It will help in development of a regional database for the Asia and the Pacific region to promote the effective coordination and partnership related to R&D and trade in MAP sector.

The Technical Session III was on 'Policy Perspective: AR4D Strategies' in which the seven panellists presented their views on overall development of MAP species. The panellists emphasized on PGR management, quality standard and safety measures and marketing and trade regulations, and suitable policies to implement good agricultural practices (GAP), good collection practices (GCP), good manufacturing practices (GMP), and good laboratory practices (GLP). Each country is to develop guidelines/monographs for good practices and quality labeling. Linkage between research and industry is lacking and needs to be developed through appropriate linkage models. Regulatory mechanism for conservation and international trade including development of quality standards of major commercial MAP species need to be developed by the member countries of the region.

Three Working Group Discussions were also organized. The Working Group 1 'Production: Conservation, Improvement, and Management' emphasized on creation of field genebanks in different climatic zones of each country, *in situ* conservation areas may be marked and declared, cultivation to be organized using cluster approach which will solve the problems of small holdings and small volumes. Plus tree selection from the diversity and their vegetative propagation method be standardized for tree and shrub species and common facilities for processing, drying, grading, packing and labelling be created at community level. The Working Group 2 'Utilization: Value Addition, Marketing, and Export' highlighted the involvement of self-help groups/local entrepreneurs/ community groups for value addition at farm level to enhance the income of farmers and collectors. Mechanism for buy-back arrangement should be developed between the producer and user industry. The better National HS Codes appropriately codified for accurate information be developed for trade in MAP species (import and export). Such efforts will facilitate better understanding of trade in each country. Knowledge exchange related to trade along with the other regulatory procedures will facilitate the effective and fair trade of MAP species in the Asia-Pacific region. The Working Group 3

'Collaboration and Networking' strongly advocated for the establishment of a Network of Asia-Pacific countries on medicinal and aromatic plants with a facilitating role of APAARI with the support of FAO and a host country to be identified to house the Secretariat of the Network. The proposed Network on MAPs will develop cooperation among the member countries at field, national and regional levels. The main responsibilities of Network will be to facilitate sharing information on research and development in member countries through dedicated website, enhance collaboration among member countries through conducting workshops/seminars/dialogues on research and development among the member countries. Where necessary, bilateral cooperation can be developed using the support of this Network for research and collaborative activities.

Various action points and recommendations pertaining to the establishment of Regional Network on MAP species through support of FAO, and facilitation role of APAARI to develop the Road Map for future directions for research, development and policy issues emerged. These proceedings cover the details of various deliberations and recommendations relating to research, development, policy and regional cooperation emanating from the expert consultation on promotion of medicinal and aromatic plants in the Asia-Pacific region.

The summary of the major recommendations related to research, development, policies and regional cooperation, as emerged in the regional expert consultation, are given below:

Research

It is recommended to prioritize the species (atleast 5-10) in each country that have high demand and comparative advantage. These species need to be accorded high priority for intensification of research, general cultivation and value addition. There is need to identify a few *in situ* conservation sites in each country following the model of Medicinal Plants Conservation Area (MPCA) and Medicinal Plants Development Area (MPDA) adopted in India since it is the most cost-effective method of conservation. The countries in the Asia-Pacific region have a wealth of information on indigenous traditional knowledge (ITK) on MAP species which needs to be documented scientifically and revalidated to benefit future R&D programmes.

The impact of herbal products invariably depends on their quality. Therefore, product quality management must be given due attention right from production of raw material to the finished product stage. To achieve this, there is an urgent need to adopt good agricultural practices (GAP), good collection practices (GCP), good manufacturing practices (GMP), and good laboratory practices (GLP) as per the guidelines of WHO.

Development

The occurrence of uncommon health problems is increasing in all age groups due to the change in life style, environmental pollution and adverse effects of chemical based products. The MAP sector has potential to address all these challenges. Therefore, MAP species be accorded proper commodity, status and designated as future crops to meet human needs.

Linkage between research and industry is invariably lacking in most of the counties and hence needs to be strengthened using innovative models. For this, partnership between public and

private sector through enabling environment and suitable policies, is needed both at national and regional levels. Also, there is need to undertake need based developmental activities to promote some major species having potential for large turnover.

There is a need to have an effective mechanism in place for coordination of all stakeholders (including collectors, cultivators, local commission agents, primary processors, industry, NGOs, R&D organizations and policy makers). Hence, a nodal organization must be identified to coordinate the activities on MAP species in each country of the region. Alternatively, a MAP Promotion Board be created, if not existing already. An urgent need was felt to encourage the involvement of self-help groups/local entrepreneurs/community groups for value addition (cleaning, grading, packaging, etc.) at farm level to enhance the income of farmers and collectors. For this, a cluster-based approach be followed to facilitate higher investment for value chain programs.

Policy

There is an urgent need to build strong institutional base so as to undertake systematic research on MAP species. For this, more institutions need to be created to undertake research and development on priority MAP species. In order to serve the communities better for their healthcare, conserve genetic diversity and harness economic gains, the level of investment in R&D needs to be tripled by each country. To achieve this goal, concerted efforts to secure additional funding from potential donor community needs to be made. Also, the required emphasis needs to be given to building much needed competent human resource, which is currently lacking in many countries of the region. Regulatory mechanism for biosafety and international trade, including adherence to quality standards, will be important to linking producers with consumers while ensuring inclusive market oriented development (IMOD). Hence, required mechanisms need to be established on priority.

Regional Cooperation

In the Asia-Pacific region, there are several MAP species which are common and for which there exists considerable traditional knowledge. Hence, the countries in the region could benefit immensely by sharing the knowledge, material and the production and processing technologies. There is definite need to develop a mechanism for knowledge exchange related to trade along with the other regulatory procedures to facilitate an effective and fair trade of MAP species in the Asia-Pacific region

There is an urgent need to develop a Regional Network on MAP species for the Asia-Pacific region. Participants unanimously resolved that FAO Regional Office in Bangkok, with needed facilitation role of APAARI, may help initially to start this Network and eventually pass on this responsibility to one of the willing NARS in the region. Also, the countries willing to join the Network need to express interest in joining the Network formally. Such Network can provide support initially for the focused activities (knowledge and technology sharing, germplasm exchange, and human resource development) for an overall development of medicinal and aromatic plants in the region.

Expert Consultation on Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region

Introduction

The Asian region has a glorious tradition on plant-based healthcare system and detailed descriptions are available in the ancient literature. The herbal system of medicine provides low cost treatment for various common diseases and several chronic ailments with safety and efficacy. The rich diversity of medicinal and aromatic plants (MAP) remains a crucial source of livelihood for majority of the forest-based communities and possess the wealth of information as indigenous traditional knowledge (ITK). Out of 8,000 species of ethnobotanical importance available in Asia, 2,500 species are primarily used in different traditional medicine systems. The modern pharmacopoeia also has about 25 per cent component of plant based drugs. At present, 134 species are under cultivation, 160 species are partially cultivated and 250 species of MAP are traded in large volumes in the region. This vast resource has formed the mainstay of raw material supply to industries for drug formulations, nutritional applications, food flavouring, perfumery, cosmetics, toiletries, etc. The international market of herbal products is estimated to be US $ 62 billion and poised to grow at a rate of 7 per cent per annum to US $ 5-7 trillion by 2050.

The increased demand of plant-based raw materials has forced the overexploitation and unscientific collection of natural populations from the wild and most of the Asia-Pacific countries are experiencing the loss of diversity of MAP. Therefore, an effective plant genetic resource management program needs to be developed by the respective National Agricultural Research System (NARS) in each country. The Asia-Pacific region is also rich in indigenous traditional knowledge (ITK) and efforts are needed to document and revalidate before it gets eroded forever. The World Health Organization (WHO) has developed the guidelines for good agricultural and collection practices (GACP). Accordingly, each country in the Asia-Pacific region should develop a set of guidelines for GACP and implement effectively at all levels to ensure the production of quality raw material. The cultivation of medicinal and aromatic plant species provides an added advantage by producing the uniform and consistent quality raw material. Therefore, the R&D efforts need to be reoriented so as to keep this sector free from the ill effects of chemical fertilizers. The efforts are required to generate ecofriendly agro-technology to support commercial cultivation under organic environment with buy-back arrangements with user industry. An effective mechanism needs to be in place for certification of organically produced MAP species in individual country with its recognition for international trade.

Though, the MAP species requires full care at each stage of production but the quality of the produce depends primarily on the correct taxonomical identification of the species and its optimum stage of harvest (where the biological yield and chemical content are optimum). The post-harvest management, monitoring the shelf life and need based value addition are equally important and require full attention of individual countries. Concerted efforts are needed for quality testing, developing quality standards, and pesticide residue analysis of the produce using faster and accurate analytical procedures.

The MAP covers large number of species and, therefore, it requires prioritization of important MAP species for research and development after taking into consideration the medicinal use, market demand and other factors. Also, larger investments are needed to create the R&D institutions and need based infrastructural facilities. The National Agricultural Research System (NARS) should develop a national strategy for research and development on MAP speceis in different countries. There is a need for complete shift in the approach from agricultural research and development (R&D) to agriculture research for development (AR4D) and to have an appropriate mechanism in place for enabling policy environment with enhanced funding support.

At present, no regulated market mechanism exists to control various marketing practices involved in the entire supply chain. Understanding of trade in medicinal and aromatic plants is far from satisfactory. The available data are not fully authenticated in the absence of required HS Code. This needs to be addressed individually at the country level and also at the regional level so that a correct picture is emerged. The farmers and collectors are not paid reasonable price of their produce and the middle men cheat these innocent people. Therefore, at producer's level, self-help groups (SHGs) and marketing cooperatives need to be created. The participation of private sector at present is minimal and, hence, it is necessary to develop public-private partnership models where the private sector also contributes through funding, helping in priority setting and also guiding the farmers for better quality of the produce. The R&D institutions should take lead role in capacity building to enhance the output of scientists to keep them abreast with advances in MAP research. A database needs to be developed on MAP species and its management at the national level involving all stakeholders from the NARS. There is a strong need to create awareness and undertake literacy campaign on intellectual property rights related to MAP speceis and training of human resource at the national and international level to make them familiar with the latest technological advancements in the MAP sector.

The countries in the region should share the knowledge, information and technology associated with MAP species. In the Asia-Pacific region, there are several MAP species which are common across the countries, and hence, there is also great need for the exchange of material of common interest for which a suitable mechanism needs to be in place. There is an urgent need to develop a regional network on MAP species in the Asia-Pacific region.

The rich diversity of medicinal and aromatic plants, its indispensable use in social, cultural and health traditions and also as a source of raw materials for plant based products in modern industries has more importance and relevance today than ever before. Any threats to these vital and natural resources will not only jeopardize the livelihoods of millions of people but also the growing global market of medicinal and aromatic plants. Therefore, this sector deserves a renewed thrust and the MAP species must be designated as future crops for human needs. The cultivation of medicinal and aromatic plants should be supported by adequate research, development and extension activities to ensure the uniform quality production for better utilization and conservation. The MAP species play a significant role in ensuring health security of millions of people globally. In the past, natural resources were the only source of livelihood for thousands of years. However, exploitation of MAP species as a source of livelihood does no longer seem a viable option due to population pressure, overexploitation, conflict of interests in land use and negative impact of climate change. In addition, the paradigm shift from common heritage of mankind to sovereignty of nations on their plant genetic resources (PGR), agreements related

to intellectual property rights (IPRs) and other international treaties call for taking due care of their native medicinal and aromatic plant resources. The significance of MAP species has risen in recent years due to substantial change in the lifestyle and negative impacts of modern chemical based products and thus, the trend of increasing requirements on quality medicinal and aromatic plant products are now visible.

In view of these facts, the Food and Agriculture Organization of the United Nations (FAO) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI) have jointly organized an Expert Consultation on Promotion of Medicinal and Aromatic Plants in Asia and the Pacific Region at FAO, Bangkok, Thailand on 2-3 December, 2013.In all, 38 delegates including policy makers from 14 countries, namely, Bangladesh, Bhutan, India, Japan, Malaysia, Myanmar, Nepal, Papua New Guinea, Pakistan, the Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam participated in the expert consultation. In addition, representatives from medicinal plants industry, FAO and APAARI, also participated. The consultation provided a platform to the participants to share their knowledge and experiences and assess future requirements and prepare the road map to accelerate the overall development of MAP sector taking into consideration the conservation of bioresources for sustainable use and produce the quality products for healthcare of people in the region. The consultation was structured in to three Technical Sessions. In the first two Technical Sessions 14 country reports were presented and discussed. In Technical Session III on 'Policy Perspective: AR4D Strategies', seven panellists presented their views on overall development of MAP species. This was followed by three separate Working Group Discussions, viz., Working Group 1: Production: Conservation, Improvement, Management; Working Group 2: Utilization: Value Addition, Marketing, Export, and Working Group 3: Collaboration and Networking. The participants were identified to join the groups based on their experiences. The in-depth discussions were held in different Technical Sessions and Working Groups and the outcomes of these discussions and recommendations were presented in the Plenary Session.

Objectives

- To assess the current status of production, utilization and conservation of medicinal and aromatic plants in Asia and the Pacific region and identify future needs of conservation and opportunities for their development
- To exchange information and share knowledge and technologies available in different countries in the region and learn from each other's experiences
- To create awareness on the value of medicinal and aromatic plants among producers in order to promote cultivation with a special focus to small scale farmers
- To identify relevant policy options for strengthening the conservation and sustainable development of these resources
- To strengthen regional collaboration and networking and develop a regional strategy for promotion and sustainable use of medicinal and aromatic plants

Opening Session

Dr. Raj Paroda, Executive Secretary, APAARI, welcomed the Chief Guest Mr. Hiroyuki Konuma, ADG, FAO RAP, the resource persons, Dr. S.P. Ghosh, Former DDG (Hort.), ICAR,

India, Mr. Ranjit Puranik representing the medicinal plants industry from Shree Dhootpapeshwar Ltd. Mumbai (India), Dr. Subash Dasgupta, Senior Plant Production Officer, FAO RAP and distinguished participants from 14 countries. He highlighted that the Asia-Pacific region has rich diversity of medicinal and aromatic plants (MAP) with associated wealth of ITK. These valuable resources are the major source of primary healthcare for 80 per cent of rural population and livelihood for millions of people through self-employment. While highlighting the importance of MAP species, Dr. Raj Paroda emphasized that these are often called as non-timber forest produce (NTFP), and now there is an urgent need for a paradigm shift and to designate MAP species as future crops for the wellbeing of humankind. He further mentioned that the MAP sector remained neglected in the past but now it requires due attention of policy planners and researchers particularly in view of their conservation and enhanced use. The need for plant diversity in MAP sector is continuously increasing due to increase in population with greater risk to health due to changing environment and life style, adverse side effects of chemical based modern medicines and other household products. People are becoming increasingly aware of the importance of returning to nature for better healthcare. In this context, the herbal products which are less expensive and safe with high efficacy attracted the consumers and are now getting increased attention.

Dr. Paroda mentioned that the MAP based products have an expanding national and international markets due to increasing demand of these products. The increased demand of raw material forced the overexploitation and unscientific collection of natural population of MAP from the forest rendering several species to vulnerable state and many of the important species are already extinct and several species are at the verge of extinction. Therefore, an effective plant genetic resource management program needs to be developed by each NARS to address the issues related to conservation and sustainable use of the genetic wealth of MAP. He stated that full attention should be given to conserve, collect, evaluate and exchange these resources for the wellbeing of humankind because these are not only the source for healthcare but also the mainstay of livelihood security of tribal communities who had been living on these resources from centuries and conserved these for posterity and use. While recognizing the contribution of communities, Dr. Paroda further emphasized that we must express our gratitude to the communities who have conserved these valuable resources and also showed us the way to use them in various ways through ITK. Therefore, conscious efforts are needed to document and revalidate the ITK properly before this wealth of knowledge disappears forever.

Some of the MAP species are also cultivated in some countries but the R&D support for scientific cultivation to make them economical and profitable is lacking. After the Convention on Biological Diversity (CBD), more awareness has been created on safe conservation and use of bioresources but at the same time the exchange of these resources became more difficult. We must also consider the issues related to biosafety for human health, and may go for organic farming of MAP species. This is high time to bridge the knowledge gap and create appropriate R&D facilities. Only a few institutions with limited human resource can not undertake the required R&D activities on all aspects of MAP species. Therefore, new institutions need to be created. All stakeholders including farmers should come together and strong partnership needs to be developed involving particularly private organizations and R&D institutes and share the knowledge and know-how for betterment of humankind. Another important area in MAP is the value addition. It has been seen that if some value is added to the product than its efficacy

increases many fold and this value addition activity should start from farmers field or collection site. This component requires high priority for R&D. A favourable environment needs to be created and all need based policy related issues should be addressed properly at individual country level and also jointly at the regional level.

Dr. Paroda further mentioned that this expert consultation on MAP was organized on the initiative of Dr. Hiroyuki Konuma, ADG FAO RAP. Through this consultation, we aim to consolidate the available information on production, R & D efforts and policy issues on MAP in the Asia-Pacific region. This was the reason that two persons, one senior level official dealing with policy issues and one scientist working on MAP were invited from each country to participate in the expert consultation. He stated that full attention should be given to conserve, collect, evaluate and exchange these resources for the wellbeing of humankind because these are not only the source for healthcare but also the mainstay of livelihood security of tribal communities who had been living on these resources from centuries and conserved these for posterity and use Dr. Paroda expressed his gratitude to the Chief Guest, Dr. Konuma for his timely initiative to organize this consultation at Bangkok and wished that under his leadership a road map will be developed. He stressed that APAARI has already identified the MAP as future crops for humanity and will support this activity in future also.

Mr. Hiroyuki Konuma, Assistant Director General & FAO Representative for Asia-Pacific (ADG, FAO RAP), the Chief Guest of the Opening Session, welcomed all the participants and resource persons from 14 countries attending the expert consultation. He mentioned that this meeting was pending for the last 3-4 years and now it has been organized with full support of Dr. Raj Paroda, Executive Secretary, APAARI. The importance of this expert consultation was very well highlighted by Dr. Paroda and I join him in saying that the MAP species are used in healthcare of larger population and provide raw material to wide range of industries in the region. These are the valuable source for livelihood security of tribal communities who lived around these resources from centuries and conserve it for humankind. The herbal system of medicine has high efficacy and is safe in use. The demand of herbal products in domestic and international markets is increasing at a faster rate. Due to unscientific collection from the forests, several species have already disappeared and many others are at the verge of extinction. This is causing greater threat to the valuable diversity and needs a clear policy at the national and regional level for their safe conservation and sustainable use. The rich indigenous traditional knowledge (ITK) available on MAP species needs to be documented and understood properly for use for the wellbeing of humankind.

In order to meet the growing demand of quality raw material for industry, the organized cultivation provide an answer and, therefore, the production and processing technologies must be worked out and effect of climate change on the quality of these resources may also be studied by the NARS in different countries. This expert consultation will prove to be very useful in knowing the present status of MAP species and their future R&D needs at the country level. It will also facilitate the development of a road map for future collaboration and networking between the countries in the region for generation and sharing of knowledge, process of utilization of MAP, awareness on use and livelihood security along with policy for production and utilization. While realizing the importance of MAP in healthcare, use in diversified industries, livelihood security of communities and preservation of ecosystem, Mr. Konuma felt the necessity of establishing

a Regional Network on MAP. This Network will address all related issues concerning MAP species with priority for conservation, sustainable production, utilization, and value addition. The Network will facilitate the sharing of experiences/technology and work in partnership mode towards livelihood security. He stressed that public-private partnership needs to be initiated in each country for technology development for conservation, sustainable utilization and value chain development. He expressed the hope that these issues will be deliberated in greater length during this consultation and a road map will be developed for future.

Dr. S.P. Ghosh, former Deputy Director General (Horticulture), ICAR, India presented the keynote paper on 'Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region'. He defined medicinal plants as those plants which provide medicines to prevent the diseases, maintain health, cure ailments and possess some major chemicals like alkaloids, glycosides, tannins, essential oils, gum resins and mucilage, etc. He stated that different plant parts are being used for making herbal products, source of drug for western medicines and also serve as model for synthesis of novel new drugs. The WHO estimated that 80 per cent population in developing countries depend on traditional medicines, mostly from plant origin and modern Pharmacopoeia also contains 25 per cent drugs from plant sources. He mentioned that China and India are the two major producers of medicinal plants in the world. He also highlighted some breakthroughs in botanical drug discovery like anti-malarial drug (*Artemisia annua*), anti-bird flu drug (fruits of *Illicium* spp.), gugulsterones as anti-hyperlipidemia drug (*Commiphora wightii*), liver protecting drug from kalmegh (*Andrographis paniculata*) and memory restorer from brahmi (*Bacopa monnieri*).

Dr. Ghosh emphasized that some restrictions are required on collection of wild plant population of MAP from the forest and advocated for a complete ban/restriction on collection of critically endangered species. There is an urgent need to prepare national inventory, focused program on plant genetic resource management and organized cultivation by each NARS. The agricultural practices (GAP), good collection practices (GCP) and good manufacturing practices (GMP) also need to be followed for production of quality finished products and it should be free from pesticides residue, microbial contaminations and heavy metals. The Asia region has long tradition of use of herbal medicines which covers the traditional Chinese medicine (TCM), traditional Indian medicine (TIM) including Ayurveda, Siddha, Unani, Tibetian medicine and others. The R&D support in certain countries has helped in stabilizing the commercial production of medicinal plants.

China has 80 per cent of its medicines from plant origin, about 7,137 species recorded as medicinal plants of which 492 species are cultivated with a significant number of improved varieties. Ginseng has been coded under Standard International Trade Classification (SITC). To conserve the genetic resources, more than 100 botanical gardens have been established. About 26 major species are under commercial cultivation on 0.83 million ha.

In India, 8,000 species have been reported to be of medicinal value of which 2,500 species provide raw material to herbal industry. The Ayurveda (900 species), Siddha (800 species) and Unani (700 species) systems are the main users and about 1,000 species are reported to have trade potential. The 54 top most traded medicinal plants are still being collected from the wild. India has a research support through Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CISR), Department of Ayurveda, Yoga

and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH) and the private sector and there are some large manufacturing units like Dabur, Zhandu, Himalayan Drug, Hamdard, etc. also working on MAP.

While concluding his presentation, Dr. Ghosh emphasized that all the Asia-Pacific countries should consolidate the species-wise data on all aspects, develop marketing network, enhance conservation and resource augmentation efforts and adopt the quality standards. He further mentioned that the present research efforts are insufficient and investment is also very low as well as thinly spread. The post-harvest technology also remained neglected. Therefore, there is an urgent need for concerted efforts to conserve, produce and use this vital resource for the wellbeing of humankind in the Asia-Pacific region.

Mr. Ranjit Puranik, Executive Director, Shree Dhootpapeshwar Ltd. Mumbai, India made an interesting and critically analyzed presentation on the status of utilization and marketing of medicinal plants in Asia and provided detailed information on the production/consumption/ export of medicinal plants. He stated that it is very difficult to get sole data on medicinal plants while some high volume botanicals have 4 digit HS codes and can be identified for trade purposes. The presentation was based on Marketing News Service Report of December, 2011 which reflects trade data for 2010-11. The world trade in botanicals is worth US $ 32.702 billion and Asian botanical trade is US $ 14.505 billion with 6.634 million tons and accounts for 44.35 per cent and 53.13 per cent of world trade in terms of value and volume, respectively. Among the top 15 countries which accounts for 72 per cent of the world trade in botanicals in Asia, China (11.48%) and the India (8.75%) are at the first and second position in world ranking in terms of value while in terms of volume, their ranking is second (9.92%) and third (8.75%), respectively. The Chinese trade covers 107 botanical counts, 51 medicinal plants commodity counts and the value of trade is US $ 3,651.79 million. The Indian trade accounts for US $ 3,050.04 million with 304 botanical commodity counts and 174 medicinal plant commodity counts.

Indonesia exports over 40 kinds of essential oils and 12 of them have reached industrial scale. The MAP species are generally high price and low volume crops by nature and the major species are lemon grass, pepper and nutmeg. It is reported that Indonesia is the largest seaweed packer and total export was set to exceed US $ 177 million. It occupies the 4th place volume-wise and 5th place value-wise. Malaysia is another important country in the region which occupies 6th rank in world trade as per the volume and 11th rank as per value. Though Sri Lanka is at 7th rank and the Philippines at 5th rank in world trade as per the value but there is no substantial HS Code-wise data available. Tea, spices, coconut are the conventional cash crops in the region. Similarly, cinnamon is also a big traded spice-cum-medicinal plant from Vietnam and Sri Lanka.

The high altitude medicinal plants from the Himalayas (Nepal, India, China, and Bhutan) play a significant role but not reflected in these data. The countries of Southeast Asia have a very rich diversity and dependence on traditional medicinal system (TMS), the data may not be compiled but consumption is surely of significance in these countries itself. Regarding the trade of rare, endangered and threatened (RET) species, he opined that it requires the efficient conservation production and utilization mechanisms.

Dr. Subas Dasgupta, Senior Plant Production Officer, FAO Regional Office for Asia and the Pacific extended vote of thanks to the Chief Guest, distinguished invitees and resource persons

as well as the participants. He highlighted the importance of MAP species and the need for developing suitable strategies for promoting the use of these species in the region.

Technical Sessions

Technical Session I: Country Status Reports – South Asia

Chair: *Subash Dasgupta*, FAO RAP, Thailand

Co-Chair: *N.M. Lita*, Philippines

Rapporteur: *M.R.B. Awang*, Malaysia

In this session, six presentations covering the country reports of Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka were made by the respective country representative. Brief summary of the presentations and major highlights of the session are given below:

Mohd. Shahjahan, Chief Scientific Officer (Forest), Bangladesh Agricultural Research Council (BARC), Dhaka (Bangladesh) made a presentation on the present status of medicinal and aromatic plants in Bangladesh. He highlighted that Bangladesh is a tropical country, has rich traditional medicinal system and about 5,000 MAP species are grown. Bangladesh has rich diversity of MAP species but no serious efforts have been made to identify these species taxonomically. Bangladesh Council of Scientific and Industrial Research (BCSIR) has identified 747 species of medicinal plants of which eight species are endangered, *Andrographis paniculata*, *Rauvolfia serpentina*, *Terminalia citrina*, *Cycas pectinata*, *Dioscorea prazeri*, *Cymbidium aloifollium*, *Amomum costatum* and *Zingiber roseum*), 191 species are harvested from nature and 29 species are imported. There is no report of comprehensive survey on area and production of MAP in Bangladesh. In 2002, plantation fortnights were started and Bangladesh Forest Research Institute (BFRI) initiated cultivation of five species, viz., *Withania somnifera* (aswagandha), *Ocimum tenuiflorum* (tulsi), *Asparagus resimosus* (satamuli), *Adhatoda vasica* (basak), and *Andrographis paniculata* (kalmegh) in the hill tract. The supply chain involved 270 seedling suppliers, 320 local service providers, 62 collection centers and 39 collectors.

Dr. Shahjahan highlighted the importance of conservation and stated that Bangladesh Forest Research Institute (BFRI) made germplasm collection of 85 rare species of MAP. Bangladesh has initiated the work on development of cultural practices for five species of medicinal plants in hilly areas and another six species were identified by the Task Force for commercial cultivation. Efforts were also made to develop the nursery raising techniques and also the extension material. Only a few incidences of diseases and pests were noted and farmers are encouraged to use bio-pesticides. Some efforts are now being made to develop quality seed and planting material by BFRI. The primary processing like cleaning, sorting, grading and drying are done by cultivators and value addition work is done by the industry but the activity requires lot of inputs and efforts. About 12,000 tons of raw material worth US $ 4.5 million is sold through rural collection and 5,000 tons of material worth US$ 8 million are imported by Bangladesh. The domestic market of herbal medicines in Bangladesh is valued at US $ 60 million. The major concerns in Bangladesh are the extinction of MAP species from natural habitat, undocumented traditional knowledge (*Biodayas* (traditional healer) don't disclose it), lack of awareness on conservation and use, lack of R&D support, poor marketing based infrastructure support. He also listed the approaches to addressing the emerging challenges

which include survey and inventorization of MAP resources, development and implementation of GAP, GACP and GMP for commercial cultivation and production through public-private partnership and networking of institutions working on MAP in Bangladesh.

Dr. Dhanapati Dhungyel, Deputy Chief Research Officer, Medicinal and Aromatic Plants, Department of Agriculture, Thimpu (Bhutan) presented the country report on medicinal and aromatic plants of Bhutan. While mentioning about the historic use of medicinal plants, he stated that Bhutan is referred to as "*Lho Jong Men Jong*", the south land of medicinal herbs and Bhutanese have been practicing the age old medical institution called as *gso-ba-rig-pa* from the eighth century. About 7,000 plant species are known to occur in Bhutan of which 600 species have been identified with medicinal properties. Most of the MAP species are collected from wild but the cultivation started from 1990s. In the 11th Five Year Plan, spices, medicinal and aromatic plants (SMAP) were given the status of a commodity program. He further mentioned that the most widely domesticated MAP species are large cardamom, ginger and turmeric. There are two distinct production sites for different MAP species in Bhutan, viz., high altitude MAP and low attitude MAP. Bhutan produces 2,284.3 tons of major MAP species valued at 479 Nu. million during 2012. The package of practices for cultivation of artemisia, lemon grass and turmeric have been developed. The Department of Agricultural Marketing and Cooperatives (DAMC) facilitates the improvement of the marketing channels of MAP. Dr. Dhungyel stated several constraints and opportunities which includes limited technical capacity, lack of good processing facilities, inadequate production of seed and planting material, lack of awareness on sustainable harvest and value addition. He stressed the need to strengthen institutional set-up, improve coordination between different stakeholders, human resource and capacity building, establishment of storage and processing infrastructure in the Bhutan.

Dr. Satyabrata Maiti, Director, Directorate of Medicinal and Aromatic Plants Research (DMAPR), Anand, Gujarat, (India) made a presentation on the current status, ongoing detailed R&D programs and overall achievements with respect to medicinal and aromatic plants in India. He stated that the ancient Indians had good knowledge on use and preparation of MAP products for medicine, cosmetics, health and hygiene, toiletries, fragrance and food supplements through its *Ayurvedic* system even 5,000 years ago. India is rich in diversity of MAP species and about 7,000 species are recorded in various folklore medicines of which 1,700 species are referred in *Ayurveda* text. At present, 134 species are cultivated widely and 160 species are cultivated partially. It is estimated that about half a million ton of raw material is collected from the wild. The Indian household industrial use and export amounts to about 319,500 million tons of raw material and 960 species of medicinal plants are traded the most.

Dr. Maiti mentioned that the export of raw material and finished herbal products is valued at about US $ 100-114 million per year. The germplasm holdings at the Directorate of Medicinal and Aromatic Plants Research, (DMAPR) and All India Coordinated Research Project on MAP (AICRP MAP) are 2,612 accessions of 39 species. Although India has *in situ* and *ex situ* conservation programs, there is an urgent need for focused program to strengthen the conservation efforts through inventorization and distribution mapping, threat categorization, conservation biology, re-introduction of extinct/threatened species in their natural habitat and development of good agricultural practices (GAP) for more species. In addition, cultivation, improved quality control as well as species improvement are needed to maintain the supply chain of raw material. The quality seed production has been initiated in some major medicinal plants like isabgol, senna,

ashwagandha, guggal, aloe, safed musali, lemon grass and palmarosa but need to be expanded along with the development of minimum seed standards. The primary processing and value addition is not adequate and requires focused attention.

He highlighted that although several marketing channels are prevalent, marketing still remains a grey area and requires an overhaul. Another important aspect is quality assurance and for this purpose, good agricultural and collection practices (GACP) and good manufacturing practices (GMP) need to be followed in the right earnest. There are several constraints in the MAP sector. It includes the high risk of commercial cultivation due to unorganized marketing. There is no policy in place to regulate the cultivation in the desired soil and climatic conditions. The candidate species are large in number which require R&D support through enhanced funding and institutional mechanism, post-harvest and value addition at farmers' fields and other need based logistic support for storage and transport. There is a great need to develop partnership with research institutes/farmers/private industrial organizations. The networking of all stakeholders should be launched by strengthening medicinal plant chain both vertically (producer–industry) and horizontally (strengthening producer organization) to increase people's trust and ability. The safety and quality of raw drugs is of paramount importance which calls for strengthening of certification (GACP and organic) and labeling. There is a great need to have a defined policy and priority setting for this vital resource.

Dr. T.P. Barakoti, Senior Scientist, Nepal Agricultural Research Council (NARC), Kathmandu, Nepal presented a detailed overview on medicinal and aromatic plants in Nepal. He stated that Nepal is gifted with a wide range of soil and climatic conditions and is, therefore, well positioned to produce large number of species of MAP in the country. It possesses eight ecological zones, 35 forest types, 75 vegetation units and 118 ecosystems. The plant wealth of Nepal covers 5,856 species of flowering plants of which 1,624 are MAP species. The country cultivates aromatic plants (mentha, chemomile, citronella, lemon grass, palmarosa and French basil) on about 968 ha area and produces 2,752 tons of essential oil. The total production of medicinal plants during 2011-12 was 2,550 tons. The wild populations of medicinal plants are the major source of raw material and local *Garau* in Tarai Tharu, *Dhami-Jhankri* in hills and *Amchi* in high hills uses the medicinal plants for preparation of various formulations for local healthcare practicing traditional systems including Ayurvedic, Homoeopathic and Tibetan. The seed production of aromatic plants and raising the plantation are done in an organized manner. The Dabur Nepal produces quality planting material of selected medicinal plant species and distributes to farmers for organized cultivation. The value addition to raw material is limited due to lack of appropriate technologies and policy support. There are over 400 various preparations made from MAP and are traded locally and also exported. Realizing the importance of conservation and to prevent overexploitation of natural populations of MAP, Nepal has banned collection, transportation and trade of 20 species of MAP.

He further mentioned that due to overexploitation, several species are under rare, endangered and threatened (RET) category, which requires attention for appropriate conservation efforts. By and large, no work has been undertaken for crop improvement and varietal development on MAP species in Nepal. There is a great potential to cultivate and produce quality raw material in Nepal, but required facilities, technological support and favourable policy environment need to be created. Nepal markets its MAP products through Indian trade hub and India gets major high altitude MAP species from Nepal. There are several constraints in production of MAP

species which require immediate attention. Due to suitable climate, Nepal has ample scope of development of MAP sector and the future thrust should be on scientific conservation, organized cultivation and value addition. For this, enhanced funding and technological support, favourable policy environment, and market linkages are extremely important and need to be addressed on priority. The sharing of knowledge and experiences as well as the partnership mode of operation are also required on priority.

Dr. M. Naeemullah, Principal Scientific Officer, Plant Genetic Resources Institute (PGRI), National Agricultural Research Centre (NARC), Islamabad, Pakistan presented the country report on MAP species of Pakistan. He presented the overall scenario of agriculture in Pakistan and stated that several MAP species are grown in Pakistan including vegetables, spices and seed species and listed about 20 species of MAP species which are largely used in primary healthcare. There are several institutes which are working on agriculture and also cover the MAP. In particular, National Agricultural Research Centre, Islamabad primarily undertakes the work on the collection, conservation, and cultivation of MAP and the Botany and Chemistry Departments take care of taxonomy and phytochemistry aspects. There are about 26 species of high altitude MAP which are endangered and vulnerable and need to be conserved on priority. Efforts were made to collect the germplasm of MAP and collected 900 accessions of 32 species. Efforts were also made to augment the germplasm through import from different countries. The germplasm characterization was undertaken in 20 species and about 350-600 accessions were characterized annually. Seed production work has also been initiated in selected MAP.

He further highlighted that only the private sector is involved in processing, value addition and marketing and 125 firms are registered with Pakistan Tibbia Pharmaceutical Manufacturing Association (PTPMA). While highlighting the constraints, opportunities and approaches for meeting the challenges, he categorically stated that there is a great need for awareness generation on all aspects of MAP among the stakeholders. He emphasized that suitable strategies should be in place for conservation and sustainable use of MAP. There is a greater need to collect and evaluate the germplasm for desired traits and expand organized cultivation with backup support of technology. There should be a national policy in place for MAP and public-private partnership approach is required to be adopted and promoted. Efforts are needed to update the inventory of MAP regarding their availability in the wild. Some communities totally depend on the wild populations of MAP for their livelihood and the income of these communities can be enhanced substantially by providing technological and policy support for on-farm value addition and product development activities. To achieve the goal, coordination and linkages among various stakeholders of MAP sector is essential.

Dr. J.A.T.R. Jayakody, Senior Lecturer, Department of Dravyagunavignana, Gampha Wickramarachhi Ayurveda Institute, University of Kelaniya, Colombo, Sri Lanka stated the importance of MAP in overall health management and economy of Sri Lanka. The country is located in the tropical belt close to the equator with mean annual temperature (20-28°C) and high rainfall (1,000 mm - 3,000 mm). There are four major vegetation zones, viz., arid zone, dry zone, intermediate zone, and wet zone which are rich in diversity of tropical plants and possess 4,143 species of flowering plants including 1,500 species of MAP and 180 endemic species. In Sri Lanka, most of the MAP species are available in forest areas which have rich diversity of aromatic plants like cinnamon, pepper, cloves, ginger, citronella, nutmeg and turmeric. The country produces 2,174 tons of cinnamon leaf oil and bark oil followed by

nutmeg, cardamom oil, clove oil and citronella oil. He also mentioned about the export of the produce of MAP along with the other agricultural produce and highlighted that Sri Lankan produce is getting popularity abroad. The future thrust of the country is on improving the productivity through research and extension efforts and giving a focused attention to value addition and product development.

While concluding the session, Dr. Subash Dasgupta emphasized that the source of data provided in each country report needs to be mentioned. He stressed that priority setting is essential for cultivation, conservation and value addition. There is also a great need to develop a Regional Network on MAP for sharing the experiences, knowledge and information. The quality management of production and use of MAP is also very important.

Technical Session II: Country Status Reports – Southeast Asia and Pacific

Chair: *Dr. T. Dhendup*, DoA, Bhutan

Co-Chair: *Dr. T. Sugino*, JIRCAS, Japan

Rapporteur: *Dr. L. Jung-Hoon*, RDA, Korea

In this session, eight country status reports on MAP were presented by the respective country representatives of Japan, Malaysia, Papua New Guinea, the Philippines, Republic of Korea, Thailand, Vietnam and Myanmar. Brief summary of each presentation and major highlights of the session are given below:

Dr. K. Nakahara, Project Leader, Biological Resources and Post-harvest Division, Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba, Japan presented the country report on MAP species in Japan. He stated that the Japanese Pharmacopoeia has listed 248 items of eastern-style herbal (*Kampo*) medicine and produces different products worth US $ 1,000 million (2007) and expected to increase it to US $ 2,000 million by 2015. Japan is a big importer of aromatic products and its domestic production of material for natural flavour and fragrance is very low. He narrated the major uses of five selected species of MAP in Japan. The National Institute of Biomedical Innovation (NIBI) is managing a collection of 4,000 species/ lines of medicinal plants. The National Institute of Agrobiological Sciences (NIAS) genebank holds more than 2,50,000 accessions including MAP. Regarding the varietal development, he stated that 20 patents were registered during 1971-1998 by private companies producing *Kampo* medicines.

In Japan, medicinal plants are mainly cultivated in a contract farming system as per an agreement between private companies and farmer groups where private companies take care for supply of quality seed and other know-how for cultivation. The cultivation practices have been developed for MAP species of major importance. The primary processing, value addition and marketing aspects are taken care of by the private companies only. He elaborated the steps from processing of raw material to finished product. The demand for *Kampo* medicine in Japan is increasing at a faster rate due to increase in the population of old people who are the main consumers. The production of *Kampo* medicines depends on import of raw drugs and therefore, government-led academia, research groups and industry have now started research projects on efficient domestic production of crude drugs. Application of hydroponic culture technique in plant factory for medicinal plant production has started only recently. In

his concluding remark, Dr. Nakahara said that crude drugs and flavour and fragrance materials (FFM) are important industrial materials, and there is a high demand for these in Japan. The domestic production of MAP has decreased considerably during the last 20 years, because most of the domestic products are much more expensive than imported material from China and other Asian countries.

Dr. W.Z.W. Mamat, Deputy Director, Malaysian Agriculture Research and Development Institute (MARDI), Kuala Lumpur presented the MAP scenario in Malaysia and stated that the herbal industry has significant demand in global and domestic markets. The major markets are looking for new, safe and effective products. Malaysia is known for *Jamu* traditional medicines. While presenting the strengths, weaknesses, opportunities and threats (SWOT) analysis, he pointed out that Malaysia is rich in diversity of MAP and associated with rich traditional knowledge but the herbal industry is still in its infancy and the wellness of multi-sectoral segments have not been fully exploited. At present, the country is concentrating on primary processing, cultivation and extraction but not on value addition. The MAP sector requires coordination among all stakeholders. He stated that five major herbs have been identified as the priority species for cultivation. Sincere efforts are being made by MARDI to establish four herbal centres of excellence, develop herbal cultivation and expand extraction facilities. Malaysia produces 35,294 tons of MAP raw material from 4,206 ha area. The country's future thrusts are directed to ensuring the production of quality seed and planting material, cultivation of selected local MAP using modern farming practices with high emphasis on post-harvest management. There is a felt need to develop value added products with desired quality and enforcement of regulations/acts which are essential to ensure sustainable production of raw material. While concluding his presentation, Dr. Mamat emphasized that herbal industry in Malaysia is new and intensive efforts are required to develop technology with full policy support to this important sector.

Dr. P.P. Rai, Professor, Division of Pharmacy, School of Medicine and Health Sciences, University of Papua New Guinea presented country report of Papua New Guinea (PNG) on MAP. The Papua New Guinea has unique geographical position and climate and is one of the largest countries in the Pacific and comprises hundreds of Islands. The largest and longest mountain range in PNG is the Owen Stanley Range that runs through the middle and dividing the country in New Guinea in the North and Papua in the South. The country is divided into Islands, the low lands (0-1,200 m asl) and the highlands (1,200-2,800 m asl). There are 800 ethnic groups originally settled with repeated rounds of colonization. About 800-850 distinct languages are spoken in the PNG and 95 per cent of the land is privately owned. PNG is the fourth mega-biodiverse country in the world and 70 per cent of its area is covered by tropical forest. The native flora contains an estimated 20,000 species of vascular plants. Scientists have estimated that more than half of the plant species are yet to be named. The nature remains a mainstay of medicines today and natural products are potential source of new drugs. PNG has several constraints and opportunities due to its geographical and geological positions and the health indicators are the lowest performing in the Pacific.

Dr. Rai further mentioned that there is no commercial or large scale planting of medicinal and aromatic plants in PNG and hence no marketing network exists. There is only small scale production of essential oils that too is limited to domestic market. About 1,000 plant species are used in indigenous traditional medicine. The bark and hardwood of *Cryptocaria massoy* contains

C-10 lactone, a golden colour oil and an experimental plot has been set-up in central province of PNG. The wariwari (*Asteromyrtus symphyocarpa*), a tree grown abundantly in western province of PNG, produces an essential oil similar to eucalyptus oil in odour and properties. A small scale sustainable essential oil industry has been set-up with Government support to generate income for local communities. He stated that there are about 20 high value MAP species which have high potential and can be grown successfully in PNG. So far, no work has been done on any aspect of plant genetic resource (PGR) management and cultivation of MAP and also no government policy is in place to promote MAP species in PNG. But, PNG is interested in developing the herbal industry because it is the part of culture and tradition, accessible and affordable with a high potential source of drug discovery. The future thrusts include the systematic survey of MAP resources, establishment of database, traditional medicine practitioners register and network, awareness and R&D support. He has listed 100 most commonly used medicinal plants in PNG.

Dr. C.C. de Guzman, Professor, University of the Philippines, Los Banos, presented the status of MAP in the Philippines. He stated that in the Philippines, general awareness about health is increasing due to increase in the proportion of aging population. The change of life style and high price and low availability of drugs have renewed the interest of people in herbal medicines. During 2012, MAP species were cultivated in about 900 ha area and 2,630 tons of raw material was produced in the Philippines. Ten medicinal plants and four aromatic plants have been identified as priority species but it also includes some fruits and vegetables. In addition, MAP species like *Coleus*, *Moringa*, and *Lagestroemia* are also considered important medicinal plants in the country. The University of Philippines, Los Banos has a collection of 73 species of MAP and a field genebank containing 180 species of MAP. The country has developed cultivation practices of 14 MAP species which also includes some fruit plants. He also presented information on diseases and pests of some major MAP species and stated that by and large no efforts have been made to develop the improved varieties and production of quality seed and planting material. However, some efforts have been made to identify the optimum stage of harvest in 10 MAP species which include some important species like citronella, lemon grass and patchouli.

He highlighted that marketing, commercialization and trade are important and the Philippines Institute of Traditional and Alternative Health Care (PITAHC) has established four processing units with a capacity of 10-15 million tablets/year. In addition, a processing unit of ilang – ilang (*Cananga odorata*) has also been established by the local Government. There are some private groups like Chamber of Herbal Industries of the Philippines Inc. (CHIPI), an umbrella group of companies (about 50) engaged in the manufacturing and trading of herbal products. Moringaling Philippines Foundation Inc. (MPFI), a network organization serving the moringa supply chain and the two major pharmaceutical companies in the Philippines, namely, Pascual Laboratories to commercialize lagundi (*Vitex negundu*) and sambong (*Blumea balsamifera*) and Rite Med, a leading unibranded unit of medicines marketing its first herbal product (Stop Cough Lagundi) from 2011. He stated that like other countries, the data published on herbal trade in the Philippines are also not adequate and the country is still a net importer of spices and essential oils. The export during 2012 amounted to US $ 206 thousand for medicinal plants and US $ 2,167 thousand for essential oils. He also highlighted the constraints, which included lack of scientific support, no standardization of natural ingredients, minimal implementation of GAP, lack of R&D support with required funding to

the natural product industry and no suitable policy environment for overall development of the MAP sector. Therefore, to address all the above emerging issues, the approach could be to establish linkages between government institutions and private organization, promote GAP, develop required R&D facilities with enhanced funding and create favourable environment for marketing with a policy support.

Dr. P. Chung-Bern, Senior Researcher, Department of Herbal Crop Research, National Institute of Horticulture and Herbal Sciences (NIHHS), RDA, Korea made a presentation on present status of MAP species in Korea. The Rural Development Administration (RDA) which is the central government organization responsible for agricultural research and extension services in Korea, has developed and disseminated the green technologies. The huge agro R&D area has been divided into three categories, viz., future high technology, on-farm technology and agro-food technology which have 15 identified priority programs. The National Institute of Horticulture and Herbal Sciences (NIHHS) is responsible for collection of new germplasm to develop new cultivars and cultivation practices for sustainable production of horticultural and herbal crops.

The medicinal crops, also called herbs, are not the minor crops anymore and have indefinite applicability as functional medicinal food material to the entire natural health industry. The R&D status of medicinal crops is expanding explicitly and the traditional processed medicinal crops have turned into new products which can be used with ease. The current research efforts include determining the origin of MAP species and their native habitats, disseminating GAP, quality standardization of products and testing their efficacy, identifying new plant based compounds to develop new drugs and establishing of medicinal herb gardens. Korea has rich tradition on use of herbal products and out of 544 species available, 450 species are listed in the Korean Pharmacopoeia as herbaceous herbs. The aging people's increasing concerns on healthcare is getting due attention because by 2025, Korea will the 6th oldest society in the world.

He highlighted that the domestic market was of Won 7.4 trillion in 2009 which was 3.1 per cent of world market. The Republic of Korea depends largely on imports (75% for food and 25% for medicine). The area under production of MAP species was 62,208 ha and the produce was valued at Won 100 million during 2011. Now the efforts are directed more to the development of herb-derived new drugs and replacing the chemically synthesized drugs. Though, Korea has 8,200 indigenous plant species but only 50 species have been domesticated so far. The integrative medicine plays a great role in promising industrialization of herbal health products. To meet the needs of consumers, functional beverage, trendy herb tea and liquor products are developed by using flavour and volatile property of various herbs. Emphasis has been laid in developing beauty products, personal hygiene items and aroma therapy materials. In an innovative effort, Korea is developing new resources to bring nature and its potential value to public.

Dr. S. Chingduang, Senior Plant Pathology Specialist, Horticulture Research Institute, Thailand presented the country status report on MAP species in Thailand and highlighted that many MAP species are used for traditional healthcare in the country and also export material worth about Baht 300,000 million of cosmetics, supplementary foods, and herbs and spices etc. The Department of Agriculture undertakes research work on plant genetic resource (PGR) management and production technology aspects and collected herb and spice plants of about

1,500 species from 5 areas in different parts of Thailand. While describing the achievements, he highlighted that in turmeric (*Curcuma longa*), two varieties, namely, Trang 84-2 and Trang 1 were developed. The research work on production technology includes standardization of plant spacing, shading, mulching, irrigation and fertilizer requirements along with the control of pests and diseases. The post-harvest and processing technology is equally important and has received focused attention of the Department of Agriculture. The quality control of products and good agricultural practices (GAP) are followed for cultivation of MAP species. The GAP registered production area is about 480 ha. He stated that 20 promising herbs have been identified for R&D efforts and presented a road map for the promotion of MAP species in Thailand (2014-19) which includes the promotion of MAP products for use in national drug industry and export, standardization of Thai products using Thai GAP and conservation of MAP genetic resources.

Dr. T.N. Hung, Senior Researcher, Fruit and Vegetable Research Institute, Trauqui-Gialam-Hanoi, Vietnam presented the country status report on MAP species of Vietnam. He mentioned that the geographical position of Vietnam is unique with 1,600 km length and 75 per cent of the land area is under hills and mountains of which the forest occupies 40 per cent. In Vietnam, 4,470 MAP species are available in wild state and are being used by different groups of people and 12,000 tons/year of herbal material is collected primarily from 206 MAP species growing in the wild. A total of 136 MAP species are cultivated commercially. The total production of MAP species based raw material is 60,000 tons/year of which 20,000 tons are being used in pharmaceutical industry, equal amount for production of popular medicines and about 30 per cent is exported. He also highlighted that MAP species have played a significant role in traditional medicines and also in the socio-cultural systems. Several hospitals, institutions and companies are involved in processing, compound extraction and developing remedies based on MAP species. He has presented significant work on important essential oils. Vietnam has undertaken *ex situ* conservation efforts for 730 species, including 86 species from the red list. The threatened species have been conserved under *in situ* conditions. The red list of MAP species covers 144 species of 58 families.

Vietnam has introduced 70 new species which are well adapted to the Vietnam conditions. Efforts are being made to provide certified planting material to the growers. He also highlighted the constraints and opportunities which include poor management, overexploitation, and sharply reduced natural forest areas. He further mentioned that the future thrust areas include development of master plan to develop MAP species associated with forestry development strategy, assessment of natural resources in key areas, building of some intensive cultivation areas, organize trainings and strengthening of interdisciplinary collaboration with different stakeholders.

Dr. Zin Zin Nwe, Deputy Director (Food Control), Department of Food and Drug Administration, Ministry of Health, Myanmar, presented the country status report on MAP species in Myanmar. Myanmar's climate is greatly influenced by the monsoon, and her 500-5,000 mm of rainfall with three distinct seasons, namely, hot, rainy and cool. Myanmar has a great tradition of use of herbal medicine and it is now becoming popular among the urban populations. He presented information on 20 important medicinal plants used in the country. In order to promote the awareness about the MAP species, Myanmar has developed nine herbal gardens (120 ha area) and six nurseries of MAP species used for the treatment of major diseases. There is one University of Traditional Medicine with two National Herbal Parks situated in Nay Pyi Taw covering 196.4 acres of land where a large collection of medicinal plants comprising 500 species are grown

and nurtured. Thankha (*Limonia crenulata*) is the famous traditional cosmetic of Myanmar since over 2,400 years. It does not produce timber but it is one of the non wood forest produce (NWFP) and also requires silvicultural practices. The bark of this tree is used for production of local cosmetics to protect skin. He further stated the success story on utilization of *Michelia champaca* for developing perfume, *Shorea siamensis* for medicinal uses like prevention of cancer cell division, malaria and also as traditional medicines and *Mesua ferrea* for medicinal purposes. The Department of Traditional Medicine is responsible for manufacturing of medicines in public sector but the private sector also plays a significant role in production of medicines and follow GMP.

In his concluding remark, Dr. T. Dhendup, Chairman of the Session emphasized that the Asian region is rich in diversity of MAP species with wealth of ITK which must be documented, authenticated and used for future R&D. There is an urgent need to create a favourable policy environment including marketing infrastructure, awareness generation at all levels. The MAP species should be designated as future crops for the humankind.

Key Highlights: Technical Sessions I & II

- The MAP species are often called as non-timber forest produce (NTFP) and remained neglected so far. Now, this paradigm need to be shifted and the MAP species should be designated as future crops for the wellbeing of humankind. Due to the changing life style and emerging uncommon health problems, there is a need for focused attention of policy planners and R&D organizations for overall development of MAP sector.
- There is an urgent need for higher investment in research and development (R&D) of medicinal and aromatic plants at national and regional level to undertake the focused activities to address the emerging issues of MAP sector.
- The institutional support to undertake R&D work and trained man power in the area of medicinal and aromatic plants is very meagre in all the Asia-Pacific countries. Therefore, more institutions need to be created (at least one institute for each climatic zone as the MAP species have distinct climatic requirements) to undertake the research work on MAP species for generation of economically viable and environmental friendly technologies for sustainable quality production and creation of trained and skilled man power.
- The MAP species are a large group, having diversified growing habits and habitats and are grown under wide range of soil and climatic conditions. Further, their different plant parts and distinct chemical compounds are used for medicinal and aromatic purposes. Therefore, it calls for the prioritization of species for cultivation, value addition and conservation efforts leading to sustainable use.
- The R&D work on MAP species is minimal in most of the Asia-Pacific countries. Therefore, the R&D activity should be reoriented involving the NARS and it should be demand driven, vibrant and capable of addressing the emerging concerns. The dedicated efforts are needed for inventorization and distribution, threat categorization, conservation biology, reproduction of rare, endangered and threatened (RET) species of MAP. There is a great need to develop effective R&D program on PGR management, crop improvement, crop production and post-harvest management, developing good agricultural practices (GAP) and adopting organic farming.

- The quality aspects are most important and should be taken care right from raw material stage to the production of finished product. There is a need for development of monographs for quality standards of all important MAP species by the respective NARS.
- There is an urgent need to have an appropriate mechanism in place for certification of organically produced raw material with defined quality in each country for the benefit of producers and users of MAP species. All herbal products need to be labeled suitably with required information on content and quality to fetch premium price in the market.
- The MAP sector comprises several stakeholders like collectors, cultivators, local commission agents, primary processors, industry, NGOs, R&D organizations and policy makers in participatory mode to effectively address the operational management issues related to the MAP species. There is a need to have an effective mechanism in place for networking of all stakeholders and a nodal organization should also be identified to coordinate the activities of MAP species in each country.
- There is a need to develop innovative system of partnership between private sector and R&D organization for reorientation of R&D efforts and also funding support from private sector organizations for major species having large turnover.
- There is lack of awareness at all steps of collection and production of MAP species in the Asia-Pacific countries and therefore, there is a great need to undertake well organized awareness programs on collection, production and sustainable use of MAP species.
- The data on collection of raw material from forests, cultivation and production, value addition and trade is lacking in the countries in Asia-Pacific region. Therefore, a mechanism needs to be developed in each country to document all such information authentically. It will help in development of a regional database for the Asia-Pacific region to promote the effective coordination and partnership related to R&D and trade in MAP sector.
- A Regional Network on MAP species needs to be established for the Asia-Pacific region which will promote the regional activities on information and knowledge sharing, exchange of human resource and material, organize trainings, workshops and seminars.
- Several species which are predominantly used as fruits, vegetables, seed spices and for other uses have also been mentioned as MAP species in various country reports and presentations. This gives an incorrect impression on overall strength of MAP species in the country/region. Therefore, only those species which have medicinal and aromatic value and are traded for this purpose should be listed as MAP species.

Technical Session III: Policy Perspective: AR4D Strategies

Chair: *Dr. S.P. Ghosh*, Former DDG (Hort.), ICAR

Co-Chair: *Mr. Khalid Mahmud*, MNFS&R

Rapporteur: *S.R. Merry*, DFRI

Seven presentations addressing the major challenges related to policy perspective for agricultural research for development strategies on MAP species were made by the experts from different countries dealing with policy issues and identified as panelists. The brief summary of each presentation and the key highlights of the discussions during the session are given below:

Mr. R. Puranik, Managing Director, Shree Dhootpapeshwar Ltd., Mumbai, India stated that the business in MAP sector should be driven by R&D support and the R&D efforts should be demand driven. Realizing the importance of correct data on collection from the wild and production from cultivation, he advocated that the MAP species should be given a commodity status. APAARI with the support of FAO should play a facilitating role in generating the required data on marketing in each country. While highlighting the market scenario, he stated that the *Ayurvedic* medicine is given a HS Code – 30049011. This HS Code is understood by creation of new HS heading (4 digits) for a product that requires a minimum of US$ 100 million international trade in that commodity and creation of a new HS sub-heading (6 digits) for a commodity that requires an international trade of US$ 50 million as per the guidelines of World Commerce Organization (WCO). The tree species remain neglected due to their long gestation period and it can be taken care by developing suitable model of intercropping with other MAP species in tree plantation to make it remunerative. There is an urgent need to understand the traditional knowledge base for 'whole plant' profile and not just the marker compound concentration. The phytochemistry of the plant is to be well understood in relation to seasonal variation and develop robust agro-technology for MAP species enabling effective use by farmers. While mentioning about 'Market Mantra', he highlighted that raw material should qualify for sustainability source, organic certification, traceability, procurement, fair trade and quality guidelines.

Dr. T. Sugino, Regional Representative, Southeast Asia liaison Office, Japan International Research Center for Agricultural Sciences (JIRCAS), Japan mentioned that Japan has established a Research Centre for Medicinal Plant Resources, National Institute of Biomedical Innovation with three R&D centres in 1874. It undertakes R&D work on all aspects of MAP species covering conservation, reproduction, cultivation, breeding and evaluation of medicinal properties, etc. Regarding aromatic plants and their essential oils, he stated that the essential oil sector has well defined policy and using functional component of aromatic plants as feed, food and developed their production and pest control technology. He also emphasized the need for developing international collaboration integrating Japan's experiences.

Dr. H.K. Manandhar, Director, Nepal Agricultural Research Council, Kathmandu, Nepal highlighted that MAP species contribute about 3 per cent of gross domestic product (GDP) in Nepal and have great potential for improving socioeconomic status of people in the mountain region. The existing policies have not clearly emphasized on MAP species as an important crop and still it is being dealt as NTFP which gets the least attention. Therefore, there is a great need to have a well-defined policy for MAP species. A separate MAP Development Board needs to be created which should include training and R&D components. Thus, there should be a well-defined public-private-partnership. A mechanism should be in place to address all the issues related to intellectual property rights (IPRs). The country also needs to develop facilities in advanced technology and quality management.

Dr. M. Naeemullah, Principal Scientific Officer, Plant Genetic Resources Institute, National Agricultural Research Centre, Islamabad, Pakistan presented the overview of MAP policy perspective in Pakistan and raised some of the important issues related to MAP sector. There is an urgent need for developing suitable strategy for development of MAP species and focused attention is required for implementation of GACP at the level of farmers, collectors and traders and developing research based production technology to comply with WHO guidelines on GACP. The registration of medicinal plant material, development of quality seed and planting material and its distribution to farmers for raising commercial plantations are to be taken up

on priority in future. There is a great need to develop better market linkages, public-private partnership and training of all stakeholders in Pakistan.

Dr. N.M. Lita, Senior Ecosystem Management Specialist, Protected Areas and Wildlife Bureau, Wildlife Resources, Division, Los Banos, Philippines mentioned that the Philippines specifically articulated a policy on traditional and alternative medicine in 1997 and the Philippine Institute of Traditional and Alternative Health Care (PITAHC) was established. Its main functions are to encourage R&D efforts, promote traditional medicines for healthcare, skill development, develop standards, guidelines and codes and formulate policies related to MAP species. He further mentioned the herbal industry in the Philippines is in the early developmental stage and full potential of MAP species is yet to be exploited. It requires collaboration between R&D institutes, private sector and other stakeholders. Enhanced investment in this sector is extremely essential to address all emerging issues related to MAP species. The quality management and marketing also need to be developed in the Philippines.

Dr. Lin Chi Vu, Head of Division, Plant Resource Center, Ankhanh Commune, Hanoi, Vietnam raised various issues related to overall development of MAP sector and stated that MAP species are high quality unique industrial plants. There should be appropriate policies for conservation and sustainable use of genetic resources of MAP, human resource development and enhanced funding support to this sector. There should be proper coordination among all players of MAP sector including public-private-partnership, documentation and understanding of traditional knowledge and also develop international cooperation.

Dr. R. Ramani, Director, Indian Institute of Natural Resins and Gums, Ranchi, India presented important AR4D strategies. He mentioned that there are large number of species of MAP and it requires priority setting under each category. He stressed on the need to develop and implement the GAP and GACP and understanding the phytochemistry in relation to plant and its environment. The input from industry should come forward to develop R&D programs of institutions. The organized cultivation is a variable option for sustainability. The tree species which require long waiting periods need a totally different strategy. The investment in R&D of MAP species need to be enhanced substantially. There is need to develop web portal of MAP species and also to develop quality monographs on each important species.

Dr. S.P. Ghosh in his concluding remarks, emphasized that four important issues are emerging out from the seven presentations made and discussed thereof. These included research and development, quality assurance, marketing and trade related aspects, and capacity building. The organic certification is a difficult job but if we go for area certification or group certification than it will not only reduce the expenditure but also will be easy in adoption. The quality parameters should also take care for heavy metals, pesticides residue, etc. and follow GAP, GCP and GMP. The Asian region in general and individual countries in particular should address these issues in addition to creation of favourable environment and enhance the investment for overall development of MAP species in the region.

Key highlights

- At present, MAP species are under the NTFP group and are being dealt with as per the code of NTFP. Realizing their vast potential, the MAP species should have a designated title and separate code of operation so that due attention is paid to this important sector.

- Since the medicinal plants and their plant parts are used in raw form in the traditional medical system, the important aspects which govern the quality of the drug at initial level are the correct identification of species, optimum stage of harvest and primary processing. All these important aspects need to be considered in the right earnest.
- A mechanism needs to be in place for growing the MAP species having buy-back arrangements with the user industry. It will ensure fair price of the produce to farmers and enhance their income to livelihood security. Efforts should be made to grow the MAP species organically and an appropriate certification system should also be in place.
- There is a need to identify the priority species for cultivation and value addition in each country and develop database on collection from wild, production from the cultivation and have effective PGR management including conservation and use of MAP species listed in the red list.
- The tree MAP species remain neglected due to their long growing period and low income during the gestation period. Therefore, suitable intercropping system needs to be developed in order to use inter-row space effectively and make the system more remunerative.
- There is a need to understand and document the ITK and based on this knowledge, the R&D efforts need to be initiated.
- There is a need to have separate MAP Board to regulate all activities related to MAP species. MAP species should also be included in the teaching curricula of State Agricultural Universities as well as traditional universities.
- In general, there is a lack of financial support to this sector. The funding support needs to be enhanced at least by three times. R&D efforts should be demand-driven and private sector should also participate with funding support to the R&D efforts. Efforts are also needed to train the staff engaged in different sectors of MAP for their skill development.
- In the present global scenario, the countries are dependent on each other, sharing experiences and exchanging the knowledge, information, material and development of man power require adequate funding support. In view of this, FAO should provide funding support for such activities related to the regional cooperation for overall development of MAP sector in the Asia-Pacific region and to developing effective international cooperation.
- There is an urgent need to prioritize 5-10 species in each country having comparative advantage of high market demand and medicinal value for cultivation and value addition. The rare, endangered and threatened MAP species need to be brought under NARS for their research and development.
- The impact of herbal products depends on quality. Therefore, quality management should be done at all stages starting from the raw material through the value chain to finished product. Hence, suitable policy needs to be developed to implement good agricultural practices (GAP), good collection practices (GCP), good manufacturing practices (GMP) and good laboratory practices (GLP). Each country has to develop appropriate guidelines for good practices and quality labeling on priority.
- There is a need to strengthen the research on MAP species through enhanced funding to meet the requirement of both domestic consumption and export. Ethnobotanical studies

(including molecular taxonomy, geographical distribution and economic significance) are the prerequisites of commercial cultivation. Leading research efforts on medicinal plants could unveil the curative measures of dreadful diseases that can be therapeutically significant in drug discovery.

- There is an urgent need to have strong linkage between research institutions and pharmaceutical industry which needs to be established through appropriate linkage model. The public-private partnership (PPP) model needs to be adopted for implementing R&D programs for overall development of MAP species. Regulatory measures for conservation, cultivation and marketing as well as quality standards of commercial MAP species need to be developed by all MAP growing countries in the region.

Technical Session IV: Working Group Discussions

Focused discussions to identify research priorities and assess the need for research and development initiatives for overall development of medicinal and aromatic plants in the Asia-Pacific region were organized involving key resource persons in the related fields and were facilitated by eminent experts. The three Working Groups were organized on various aspects: i) Production: Conservation, Improvement, Management; ii) Utilization: Value Addition, Marketing, and iii) Collaborations and Networking.

Working Group 1. Production: Conservation, Improvement, Management

Facilitator: *Dr. S. Maiti*

The first group involving 13 participants from the Asia-Pacific countries, APAARI and FAO had in-depth discussion on prioritization of MAP species for organized commercial cultivation, crop improvement and conservation efforts, and need assessment for future R&D activity on MAP species in the Asia-Pacific region. The key issues/recommendations emerged were presented and discussed by all participants of the expert consultation collectively in a separate plenary discussion session.

Working Group 2. Utilization: Value Addition, Marketing, Export

Facilitator: *Dr. R. Ramani*

The second group comprising ten participants discussed and finalized issues and recommendations related to the utilization component of the raw material and value added products and also covered the marketing and export of MAP species. The group identified important aspects of value addition at farmers' fields through investment for supporting the common facilities, developing the organized marketing and labeling of the herbal products. The group also felt the need of a separate HS Code for MAP. The key issues/recommendations emerged were presented and discussed by all participants of the expert consultation collectively in a separate plenary discussion session.

Working Group 3. Collaboration and Networking

Facilitator: *Dr. Subash Dasgupta.*

The third group involving nine participants dealing with policy issues in different Asia-Pacific

countries, key resource persons from APAARI and FAO had in-depth discussion to develop the regional cooperation and create a network on MAP species for the Asia- Pacific region with the support of FAO and facilitation role of APPARI. The key issues/recommendations emerged were presented and discussed collectively by all participants of the expert consultation in a separate plenary discussion session.

Plenary Discussion on Recommendations of Working Groups

Moderator: *Dr. Raj Paroda*

In this special session, the recommendations of three Working Groups were presented by the respective Group Convener, viz., Working Group 1. Production: Conservation, Improvement, Management by Dr. S. Maiti; Working Group 2. Utilization: Value Addition, Marketing, Export by Dr. R. Ramani; and Working Group 3. Collaboration and Networking by Dr. Subash Dasgupta. The group recommendations were further discussed collectively by all the participants and were refined based on valuable inputs from the experts across the groups. The key recommendations emerged are given below group-wise:

Recommendations

Working Group 1. Production: Conservation, Improvement, Management

- Medicinal and aromatic plants (MAP) are large in number and hence 5-10 species need to be prioritized based on the medicinal value and market demand for efficient R&D management. The RET species should be given top priority for conservation efforts. At least one field genebank needs to be established in each climatic zone in each country for conservation and utilization of MAP species.
- *In situ* conservation is the cost-effective method for conservation. A few *in situ* conservation areas may be earmarked and declared protected areas in each country following the model of Medicinal Plants Conservation Area (MPCA) and Medicinal Plants Development Areas (MPDA) as adopted in India.
- Development of varieties with improved quality should be given greater thrust for enhancing their conservation. Exchange of improved varieties of MAP species between the countries on bilateral basis needs to be encouraged.
- To ensure the sustainable harvesting of MAP species from forest and systematic cultivation, each country should develop the GACP as per the guidelines of WHO and implement faithfully at all steps from collection to production in order to produce quality raw material. The species collected most from the forests may also be brought under cultivation and this needs to be organized following the cluster approach to solve the problems of smallholder and small volumes.
- The tree MAP species are more vulnerable to extinction as their bark and root are used. Therefore, a sustainable harvesting method by staggered harvesting and replanting in accordance with the harvesting cycle need to be adopted. Plus tree selection from the available diversity and their vegetative propagation method should be standardized for tree and shrub species improvement.

- There is lack of post-harvest facilities at the level of communities' due to their low income. Therefore, there is a need to develop common facilities for drying, grading, packing and labeling at the community level for common access to all the small farm holders and small gatherers. It will greatly facilitate the post-harvest processing at the ground level.
- The MAP species are being handled by various departments/ministries in most of the countries that results in poor coordination. A suitable mechanism should be developed in each country by identifying a nodal organization to coordinate the activities on research and development being undertaken by various organizations working on MAP species. Awareness programs among the stakeholders also need to be organized periodically.
- Several innovations have been made in the past using the ITK. Therefore, efforts are required to document and revalidate the valuable MAP wealth before it gets extinct forever. The documentation of ITK will empower the communities to raise their voice for benefit sharing.

Working Group 2. Utilization: Value addition, Marketing, Export

- Guidelines on good agricultural and collection practices (GACP) need to be developed and implemented at all stages from collection to cultivation in each country for production of quality raw materials.
- Encourage involvement of Self-Help Groups/local entrepreneurs/community groups for value addition (cleaning, grading, packaging, labelling etc.) at farm level to enhance the income of farmers and collectors. The cluster-based approach needs to be followed to facilitate higher investment for betterment of community based value chain programs.
- Efforts are needed to develop the database on production, processing, trade of raw material and the finished products of MAP species in each country to facilitate the development of regional database for the Asia-Pacific region.
- At present, the researcher-farmer-industry linkage does not exist in most of the countries to know the demand and supply of the MAP species. This type of linkage needs to be developed with involvement of SHGs and contract farming groups. Mechanism for buy-back arrangement should be developed between the producer and user industry.
- Globally acceptable certification (organic produce with defined quality) needs to be linked with the local certifying agency through credibility building for end user along with good labeling code with complete disclosure of details to facilitate transparent export and trade.
- Better national HS Codes appropriately codified for accurate information should be developed by approaching the national and international authorities dealing with the allotment of HS Code for trade in MAP sector (import and export). Such efforts will facilitate better understanding of trade in each country.
- Knowledge exchange related to trade along with the other regulatory procedures needs to be promoted to facilitate the effective and fair trade of MAP species in the Asia Pacific region.

Working Group 3. Collaboration and Networking

- A Network of Asia-Pacific countries needs to be established with a facilitation role of APAARI and funding support of FAO. A host country also needs be identified to house the secretariat of the Network. The proposed Network will develop cooperation among the member countries at the national and regional levels
- The main responsibilities of Network will be to facilitate sharing information technology and material, enhance collaboration among member countries through conducting workshops/ seminars/dialogues on research and development among the member countries through dedicated website. Where necessary, bilateral agreements should be adopted to further the research and collaborative activities through the exchange of experts and material transfer.

Plenary Session

Chair: *Dr. Hiroyuki Konuma*, FAO RAP

Co-Chair: *Dr. Raj Paroda*, APAARI

Rapporteur: *Dr. Bhag Mal*, APAARI

The key highlights and recommendations emerged from different technical sessions, and working groups were presented by rapporteurs and convenors. The overall synthesized general recommendations of the expert consultation were presented by Dr. Bhag Mal, Consultant, APAARI. The reflections and remarks by the Chair and Co-Chair and the key recommendations relating to research, development, policy and regional cooperation are given below:

Dr. Raj Paroda, Executive Secretary, APAARI in his concluding remark emphatically mentioned about the need for conservation of MAP resources and health security of the people of the Asian region. He stressed that MAP sector now requires full attention of all stakeholders in view of the adverse effect of chemicals on health and environment and the fact that the world is looking towards these resources for their healthcare. In order to achieve health for all, more systematic and scientific work is required to be done on all aspects particularly on safe conservation and sustainable utilization of wild populations in the forest areas. He emphasized on the need of documentation of valuable wealth of information available as ITK before it is lost forever. The data on MAP species must be validated and authenticated. While stressing on the development of database for MAP species, he suggested that an authentic documentation and information management system should be in place on all aspects of MAP sector in each country to facilitate the development of database for the Asia-Pacific region and for this purpose, each country should identify a nodal person and the organization to take up the responsibility for database development. He also stressed on the need for recognition of the role of communities that had been conserving these resources from centuries and draw their livelihood thereby protecting the ecosystem. The contributions of communities must be recognized and they must be compensated and suitably rewarded for their valuable contributions. Greater emphasis is now required to be given on conservation, utilization, exchange of PGR and help communities in restoring the lost germplasm. There is an urgent need to develop a road map which calls for collective work and catalyzing the efforts of each sector. He further highlighted that greater coordination is required among all stakeholders and sectors of MAP particularly the forestry sector which still caters to the needs of raw material.

The organized cultivation of priority species should be taken up with technological support with tie-up arrangement with user industry. It calls for strengthening the national system and developing an effective national program on MAP species. Based on the needs of the national programs, the regional requirements can be worked out and the proposed Regional Network may take up activities to address all such issues. Also, an effective mechanism of public-private partnership needs to be developed. The private sector should come forward and play an important role by investing in R&D, help in prioritizing the species and link farmers at the national and international level. Through this mechanism, the farmers/forest dwellers will come on the forefront and will be effective players in implementing programs related to MAP species. Several issues related to intellectual property rights (IPRs) also need to be addressed. Dr. Paroda highly appreciated Mr. Hiroyuki Konuma, ADG, FAO RAP for taking this initiative and stated that FAO and APAARI should jointly undertake this responsibility. He profusely thanked all the participants for attending the expert consultation.

Mr. Hiroyuki Konuma, Assistant Director General and FAO Regional representative for Asia and the Pacific, in his concluding remarks emphasized on three major areas of MAP species, viz. conservation, sustainable utilization and value chain development. He stressed on the need for developing a website on medicinal and aromatic plants for the Asia-Pacific region and FAO will support this activity. He emphasized that there should be a favourable policy environment to address emerging issues on medicinal and aromatic plants and each country should develop a national policy for conservation and use of MAP species. All R&D programs should be need based and be reoriented and FAO will provide support for activities having wider impact. He also mentioned that the public-private partnership should be strengthened and more and more interaction should be held among all stakeholders. Now the growing demand for quality products of MAP species is increasing. In order to meet the demand, there is a need to pay more attention on quality, value addition and at the same time on safe conservation and sustainable utilization of these resources. He highlighted that it is for the first time that a regional level consultation on MAP species has been organized in partnership with APAARI and through the Regional Network, we would like to continue these efforts through such consultations after every 2-3 years with the involvement of all related stakeholders. He emphasized on the need for all stakeholders to come together to save, conserve and use these valuable resources for the humankind. He thanked APAARI for collaboration and all the experts and participants for sharing their views, knowledge and experiences and felt great satisfaction on the outcomes of the expert consultation and the recommendations that emerged.

Dr. Bhag Mal, Consultant, APAARI extended vote of thanks to the organizers, Co-Sponsors, Chairs/Co-Chairs/Convenors/Rapporteurs/Speakers and the participants attending the regional consultation. He highlighted that the expert consultation was highly successful, expected outputs were achieved and a future road map for research and development on MAP species was developed.

Major Recommendations

The medicinal and aromatic plants do play a significant role in ensuring health security of almost 80 per cent of the world's rural population. These are the main source of livelihood for forest-based communities and also the basic raw material for the industries. According to

WHO, the goal of 'Health for All' cannot be achieved without the use of herbal medicines. The demand for herbal medicines/products is also increasing as people are becoming more health conscious and looking for safe alternatives such as traditional medicines. In this context, APAARI and FAO Regional Office in Bangkok organized this expert consultation on medicinal and aromatic plants to deliberate on status and role of MAP for human health in the region.

The major recommendations related to research, development, policies and regional cooperation emerged in the regional expert consultation, are given below:

Research

- There is an urgent need to prioritize the species (atleast 5-10) in each country that have high demand and comparative advantage. These species need to be accorded high priority for intensification of research, general cultivation and value addition. Also, the rare, endangered and threatened (RET) species need to be given due importance for their evaluation and conservation.
- There is need to identify a few *in situ* conservation sites in each country following the model of Medicinal Plants Conservation Area (MPCA) and Medicinal Plants Development Area (MPDA) adopted in India since it is the most cost-effective method of conservation.
- The countries in the Asia-Pacific region have a wealth of information on indigenous traditional knowledge (ITK) on MAP species which needs to be documented scientifically and revalidated to benefit future R&D programs.
- There is need to strengthen research work on MAP species in important areas like ethnobotany (including molecular taxonomy), inventorization and distribution, economic significance and threat categorization, genetic resource management, crop improvement, crop production, organic farming, post-harvest management and processing/value addition in order to develop economically viable and ecofriendly technologies for the production of MAP species.
- The impact of herbal products invariably depends on their quality. Therefore, product quality management must be given due attention right from production of raw material to the finished product stage. To achieve this, there is an urgent need to adopt good agricultural practices (GAP), good collection practices (GCP), good manufacturing practices (GMP), and good laboratory practices (GLP) as per the guidelines of WHO.
- Research efforts towards the discovery of medicinal plant based new drugs, especially for therapeutic use against various pharmacological targets, would require strong institutional as well as funding support. State-of-the art bioactivity and biosecurity screening technologies would be needed to harness full benefits from MAP species in the region.
- The medicinal plants and their plant parts are often used in raw form in the traditional medical system. Therefore, it is necessary to have correct taxonomical identification of species and these be harvested at optimum stage for appropriate primary processing. Also, the quality of such raw materials should also qualify the pharmacopoeia and essential oil standards. To achieve these objectives, the countries in the Asia-Pacific region should develop proper guidelines/monographs for good practices, including the labeling for quality requirements.

- The tree MAP species have invariably remained neglected due to their long growing period and low income potential during the gestation period. Therefore, suitable intercropping systems need to be developed in order to use inter-row spaces effectively for increased profitability.

Development

- The occurrence of uncommon health problems is increasing in all age groups due to the change in life style, environmental pollution and adverse effects of chemical based products. The MAP sector has potential to address all these challenges. Therefore, MAP species be accorded proper commodity status and designated as future crops to meet human needs.
- Linkage between research and industry is invariably lacking in most of the counties and hence needs to be strengthened using innovative models. For this purpose, partnership between public and private sector through enabling environment and suitable policies, is needed both at national and regional levels. Also, there is need to undertake need based developmental activities to promote some major species having potential for large turnover.
- There is a need to have an effective mechanism in place for coordination of all stakeholders (including collectors, cultivators, local commission agents, primary processors, industry, NGOs, R&D organizations and policy makers). Hence, a nodal organization must be identified to coordinate the activities on MAP species in each country of the region. Alternatively, a MAP Promotion Board be created, if not existing already.
- An urgent need was felt to encourage the involvement of Self-Help Groups/local entrepreneurs/community groups for value addition (cleaning, grading, packaging, labeling etc.) at farm level to enhance the income of farmers and collectors. For this, a cluster-based approach be followed to facilitate higher investment for value chain programs.

Policy

- The number of MAP species grown is quite large in many countries and only a few institutions can not undertake the required R&D activities. Hence, there is an urgent need to build strong institutional base so as to undertake systematic research on MAP species. For this, more institutions need to be created to undertake research and development on priority MAP species.
- In order to serve the communities better for their healthcare, conserve genetic diversity and harness economic gains, the level of investment in R&D needs to be tripled by each country. To achieve this goal, concerted efforts need to be made to secure additional funding from potential donor community. Also, the required emphasis needs to be given to building much needed competent human resource, which is currently lacking in many countries of the region.
- Better National HS Codes, appropriately codified for accurate information should be developed by building linkages with the national and international authorities dealing with the allotment of HS Code for trade in MAP species (import and export). Such efforts will facilitate better understanding and accelerate trade in each country.

- Regulatory mechanism for biosafety and international trade, including adherence to quality standards, will be important to linking producers with consumers while ensuring inclusive market oriented development (IMOD). Hence, required mechanisms need to be established on priority.

Regional Cooperation

- In the Asia-Pacific region, there are several MAP species which are common and for which there exists considerable traditional knowledge. Hence, the countries in the region could benefit immensely by sharing the knowledge, material and the production and processing technologies.
- There is a definite need to develop a mechanism for knowledge exchange related to trade along with the other regulatory procedures to facilitate an effective and fair trade of MAP species in the Asia-Pacific region
- There is a need for validation of data at each country level in order to develop a regional database on MAP species covering (a) list of medicinal plants being cultivated on commercial scale (b) list of medicinal plants collected from wild, and (c) list of species on which valuable information on GAP and GMP are already in place/pipeline but not well documented.
- There is an urgent need to develop a Regional Network on MAP species for the Asia-Pacific region. Participants unanimously resolved that FAO Regional Office in Bangkok, with needed facilitation role of APAARI, may help initially to start this Network and eventually pass on this responsibility to one of the willing NARS in the region. Also, the countries willing to join the Network need to be express interest in joining the Network formally. Such Network can provide support initially for the focused activities (knowledge and technology sharing, germplasm exchange, and human resource development) for an overall development of medicinal and aromatic plants in the region.

Lead Papers

Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region

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Introduction

Medicinal and aromatic plants (MAP) are botanical raw materials that are primarily used for therapeutic, aromatic and/or culinary purposes as components of medicinal products, health foods and other natural health products. Plant based herbal medicines have been used for thousands of years in many parts of the world. The therapeutic use of herbal medicines is gaining considerable momentum in the world during the last decade. The World Health Organization (WHO) estimates that herbal medicine is still the mainstay for primary healthcare of about 80 per cent of world population, mainly in the developing countries. The use of botanical raw material is in many cases much cheaper than to use chemical alternate substances. As a consequence, there is an enormous demand for botanicals in domestic use and commercial trade in the international market. The chemical ingredients that make a plant valuable for medicinal use are: i) alkaloids (additives, pain killing effects); ii) glycosides (heart stimulants, purgative, better sexual health); iii) tannins (used for gastro-intestinal problems, like diarrhea, dysentery, ulcer, skin diseases); iv) essential oils (facilitates digestion, insect repellents); gum resins and mucilage (analgesic, suppress inflammation, mild purgatives); and v) vitamins and minerals (fruits, vegetable sources). With respect to therapeutic category, the uses of botanical medicines are mainly to treat: i) cardiovascular disorders, ii) respiratory disorders, iii) GUT disorders, iv) CNS disorders, and v) skin disorders. Also, botanical products are being used as dietary supplements.

Modern Pharmacopoeia contains about 25 per cent plant drugs. China has made very good progress in utilizing herbal wealth by promoting its use in the developed world. In China, the annual herbal production is worth US$ 48 billion, with export of about US$ 3.6 billion. (Sangita Kumari *et al.*, 2011). Global market for all categories of herbal products estimated at US$ 62 billion. European Union (EU) countries, USA, Japan, Hongkong, Korea, and Singapore are the major export markets. The global market for botanical and plant derived drugs increased from US$ 9.5 billion in 2008 to US$ 32.9 billion in 2013, at an annual growth rate of 11.0 per cent according to a 2009 study by BBC research (Source: International Trade Centre, Market News Service, http://www.intracen.org/trade support/medicinal plants/).

Importance

Plant based healthcare products, particularly drugs, provide a valuable linkage between

affordable appropriate healthcare, sustainable eco-preservation of plant species and improved livelihood for rural communities near the habitat of these plants. About 100 plant species are involved in 25 per cent of all drugs prescribed in advanced countries. WHO registered 2,000 acute and chronic human diseases out of which 30 per cent are curable. However, almost one third of global population has no access to the drugs of choice. Finished products made from medicinal plants are increasingly in demand and at present nearly 4 billion people of world use plant derived healthcare products.

Most of the drug leads from natural products have emerged from medicinal plants or microbial sources. Increasingly plant biodiversity is being bio-prospected and intensive bio-screening directed to new drug discovery has started paying dividends. Of the current modern medicines, 40-50 per cent drugs are derived from natural products obtained from plants and this percentage goes beyond 70 per cent for oncology and anti-infectives. It is reported that over 6 per cent of 877 small molecule - new chemical entities (NCE) introduced world wide as drugs during 1981-2000 can be traced to or were inspired by natural products (Handa, 2013). More and more diseases are being treated with combinations of many single component drugs. Ability

Steps to single molecule natural product drug discovery

- Screening medicinal plants for desirable biological activities and identification of compound with selective and specific biological effects for target diseases.
- For isolation and structure elucidation of active constituent(s), a system of prioritization and de-replication process need to be developed. Development of reliable methods of de-replication may reduce the laborious, time consuming and expensive steps in natural product drug discovery system. The goal of de-replication is to select only the extracts that are likely to yield novel chemotypes.
- Structural characterization of isolated active compounds is accomplished mostly using spectroscopic and chromatographic techniques such as LC-MS, LC-MS-MS.
- Therapeutically potential new compounds (based on biological activity) considered as promising pharmaceutical candidates are to be selected for pre-clinical studies and clinical trials.
- Synthesis and isolation from plant material have been the most consistent in providing large quantities of selected plant derived compounds.
- The botanical sources identified to provide the following classes of NCEs for drug discovery process included: i) herbal extracts as botanical drug e.g. green tea extract; ii) bioactive compounds for direct use e.g. dioxin, and iii) lead compounds (e.g. paclitaxol from *Taxus* sp.) as potent drug.

Steps to traditional medicine and crude extract based natural product drug development

- Revealing the chemical and pharmacological profiles of extracts for possible therapeutic applications, efficiency testing of mono-substance therapy and potentiality of drug combinations consisting of two, three or more single component drugs are essential.
- For easy acceptance into main stream medicine system, there is a need of developing innovative scientific methods for discovery, validation, characterization and standardization of plant based multi-component therapeutics. Research preparedness in this area is still inadequate in many of the developing countries in Asia and the Pacific region. Quality and safety for herbal medicines are of great concern and need priority research attention for resurgence of interest in drugs from plants, particularly in developed countries.

of plant secondary metabolites (curcumin, quercetin, reseveratrol, catechins, etc.) to potentiate the activities of various anti-cancer drugs and other phytochemicals is being established increasingly. In addition, some plant secondary metabolites have been shown to overcome drug resistance in tumors.

Several new techniques of extraction, fractionation and isolation are now available enabling faster studies on bioactive phytoconstituents essential for newer drug discovery from plant resources. State-of-the art bioactivity screening techniques are now available to screen *in vitro* bioactivity and pharmacological selectivity of constituents of plant extracts. Separation of bioactive phytoconstituents is being attempted in many laborations and there is a need to develop new miniaturized analytical / instrumental methods to speed up drug discovery. It is believed that structural diversity of natural product mixtures has edge over synthetic chemicals. Combination of traditional knowledge using indigenous bioresources and modern state-of- the art technologies (extraction, fractionation, isolation, fast bio-screening along with analytical instrumentation) will lead to faster botanical drug discovery.

Recent Developments in Botanical Drug Discovery

Nutraceuticals / functional foods and perfumery/aroma chemicals from natural sources is the fastest growing sector in the global market of medicine. Some examples of recent breakthroughs in botanical drug discovering of good impacts are as follows:

Anti-malarial drug: Discovery of Artemisin from *Artemisia annua* as anti-malarial compound, especially for cerebral malaria. One third of world population is exposed to the risk of malaria.

Anti-bird flu respite: The avian-influenza resulting in bird flu caused by HSNI virus can be managed through Tamilflu drug Oseltamivir produced through a 12 steps synthesis, starting from a plant product, the shikimic acid, obtained from the fruits of *Illicium verum* (Chinese star anise) and *Illicium griffithi* (Indian star anise). At present, this is the only drug available for bird flu (Handa, 2013).

Anti inflammatory property: Turmeric (*Curcuma longa*) rhizome is being increasingly used for remedy for a number of inflammatory conditions. The pigment curcumin in turmeric rhizome has multiple uses. Non-steroidal, non-aspirin like anti-inflammatory drug is reported from gum resin of *Boswellia serrata*.

Other leads: Oleogum resin from *Commiphora wightii* (*gugul*) for use as *anti-hyperlipidemic* drug (standardized on the basis of bioactive gugulosterone E and Z); some liver protecting drugs form *Picrorhiza kurooa*, *Andrographis paniculata*, *Schizandra chinensis* are showing good promise. Compounds such as 'reserpine' from *Rauvolfia serpentina* and '*paclitaxol*' from Himalaya yew (*Taxus wallichiana*) have important pharmaceutical uses in Europe and USA.

Diseases like diabetes, cancer, arthritis, asthma, depression and heart ailments are associated with both genetic and environmental risk factors. Single ingredient drugs known as new chemical entities (NCEs) often fail to cure such diseases. The plant secondary metabolites offer significant therapeutic opportunities to address such diseases. Drug regimes containing several active components have been used in both Indian Ayurvedic and Chinese systems of medicines, where mixtures of plant extract are considered integral to therapy. It should not be overlooked that biological activity of plant extracts often results from additive or synergistic effects of its components.

International Trade

The herbal products industry comprises a number of inter related sub-section including, i) phytochemicals; ii) functional food; iii) nutraceuticals; iv) herbal teas; v) ethical OTC medicines; vi) flowers and fragrances; vii) aroma therapy; viii) culinary and spices use. Functional food alone enjoys a market of about US$ 2.0 billion in Europe and US$ 5.0 billion in USA, mainly for improvement of gut health, heart health, bone health and immune function. Out of many uses, the most popular selling herbal medicines in USA are shown in Table 1.

Table 1. Ten best selling herbal medicines in USA

Drug	Botanical name of species	Market rank as per sale	Drug	Botanical name of species	Market rank as per sale
Echinacea	*Echinacea species*	1	Saw palmeto	*Serenoa repens*	6
Garlic	*Allium sativum*	2	Aloe vera	*Aloe barbadensis*	7
Goldenseal	*Hydratis canadensis*	3	Ephedra	*Ephedra species*	8
Ginseng	*Panax species*	4	Eleuthero	*Eleutherococcus senticosus*	9
Ginko	*Ginko biloba*	5	Cranberry	*Vaccinium macrocarpon*	10

(Adapted from Sangita Kumari et al., 2011)

Plant parts of medicinal species include - whole plant, roots, leaves, flowers, fruits, seeds, stem, bark and wood. Destructive harvest of the species in which whole plant and roots are mainly used is an ecological concern, particularly when collected from wild. Many such valuable plants now fall under rare, endangered and threatened (RET) categories.

China and India are the world's leading producing countries, whereas Hong Kong, USA and Germany are the important trade centres (Dagmar Lange, 2004). China is a major growing and manufacturing center for herbal extracts and finished products. In addition to wild collection, role of cultivation in meeting pharmaceutical demand is expanding through R&D support in selection of cultivars, rapid propagation of quality planting material and other good agricultural practices. In some areas, MAP species are playing central role in income generation of small and marginal land holders. Of late, wild collections and trade of medicinal plants, mainly in Asia, are being growingly regulated for collection, transit and export. Traditional medicine practitioners prefer wild collected raw materials but R&D efforts in a few species have been able to establish that cultivation rather than wild collection, is a preferred option for sustainable development. Medicinal and aromatic plants, namely, opium poppy (*Papaver somniferum*); isabgol (*Plantago ovata*), senna (*Cassia angustifolia*), mentha spp (*M. arvensis*, *M. spicata*), aloe (*Aloe barbadensis*), *aonla* (*Emblica officinalis*), kalmegh (*Andrographis painculata)*, long pepper (*Piper longum*), *Cymbopogan* spp. lemon grass; *Citronella* grass and others are cultivated as crops in India.

In China, important cultivated crops are *Penax ginseng*, *Angelica sinensis*, *Coptis chinensis*, and *Paeonia suffriticosa*. It is reported that more than 100 species are cultivated on a commercial scale. In addition, some plant species originated in Asia are cultivated on a

commercial scale in Europe and other countries. For example, *Gingko biloba*, native to Southeast China and *Strychnos nux-vomica*, native to South Asia, are cultivated in Europe and China, respectively.

For pharmaceuticals ranging from digitalis to vincristine, the ethnobotanical approach to drug discovery has proved to be successful. In traditional medicine systems, both in India and China, the raw materials are still sourced from the wild. Northeast Himalayan region of India, Nepal, Myanmar and other countries are rich source of wild collections. It is reported that in Nepal, every year more than 15,000 tons of herbs are collected from the wild (Bhattaria, 1997). The loss of genetic diversity through destructive harvesting and overexploitation may cause enormous problems in the context of sustainable development of MAP.

Global Trends in Use of Essential Oils

Aromatic plants and their products, particularly the essential oils, are now becoming one of the most important export items from many developing countries of Asia. Natural essential oils, the volatile extracts from aromatic plants, are chemical compounds with an odoriferous nature, insoluble in water but soluble in organic solvents. The term 'essential' refers to the presence of an essence or odour and the term 'oil' is used because when these compounds are placed on a transparent paper, they leave behind an oil spot.

Recent advances in chemistry have led to development of technology for preparation of individual odoriferous principles from the aromatic plant materials. Now, there are large essential oil production units which are engaged not only for isolation of the suitable aromas but also blend them to use for perfumes, industry and in making a great variety of products ranging from food, medicine, cosmetics, toiletries, paints, insecticides and a lot of several other products.

World's total production of essential oils is estimated at about 0.10 to 0.11 million tons. Brazil with its production of citrus oil at 40,000 tons is the largest producer of essential oils in the world. In terms of value, India stands in second position with a world share of 21-22 per cent. Among the essential oils, Japanese mint oil, ambrettee seed essence, sandal wood oil, *Citronella* oil, lemon grass oil, palmarosa oil, ginger oil, clove oil, eucalyptus oil, vetiver oil, pepper oil, patchouli oil, etc. India has become largest producer of mint (*Mentha arvensis*) and basil (*Ocimum basilicum*). In recent years, jasmine oil and tube rose oil have made a debut in the world market. Essential oils can be increasingly utilized in diversified areas. In the Northeastern region of India, both patchouli and himalomena aromatic oil are being increasingly produced. Ginger oil and oleoresins are also in use.

Dental care: World's consumption of essential oils and its fractions such as menthol, eucalyptus, carvone, anethola and methyl salicylate in dental care sector is estimated to be 10,000 - 12,000 tons valued at US $ 150 million.

Flavours/Fragrances: The demand for natural flavours is increasing since perception has changed in favour of flavours, which are considered as safe. Consumption of flavours / fragrances was estimated to be of US $ 10,000 million worldwide. Flavours and fragrances, are the two most important sectors covering about 70 per cent within essential oil groups. Out of present market of flavours, 50 per cent comes from natural flavours, the value of which is

estimated at US $ 1,200 million. USA and Western Europe together account for 62 per cent of consumption. If Japan is also included, the three major industrial regions with only 15 per cent of world's populations account for 78 per cent of the consumption. Many diverse aroma isolates are sought by the industry for manufacturing of various blended flavours.

Essential oils and herbal extracts and their value added products are to be considered as "Commodity" and vigorous marketing and promotional drives are needed. Many countries are making huge investments in promoting their commodities e.g. tea tree oil and eucalyptus oil by Australia, citrus oils and mint oils by USA, citrus oils by Italy, lavender, rosemary, thyme oils by Spain and rose oil by Turkey and Bulgaria.

Conservation of MAP Genetic Resources

According to the estimates of Medicinal Plants Specialist Group of the IUCN Species Survival Commission, the number of medicinal plants which are threatened word wide is at least 10,000 species (Leaman, 1998). In case of medicinal and aromatic plants, conservation approach should meet both i) future supply, and ii) genetic resource conservation.

According to IUCN, WHO and WWF (1993) the cultivation of medicinal and aromatic plants is the best effective way to satisfy the market demand. Good agricultural and collection practices (GACP) for medicinal plants have accordingly been developed through WHO and other initiatives. MAP species are of high priority for conservation action, as wild collections are likely to play a significant role in the future trade. In more recent times, the conservation strategies have been drawn in many countries, including India. The basic principles include:

- The protection of species (in the wild) through restrictions in collection for trade
- In case of critically endangered species, a complete ban for trade and export
- Development of adequate general and species specific management programs, including *in situ* and *ex situ* conservation strategy and guidelines for sustainable collections, may be supported by an effective certification system
- National inventory of the rare and endangered species of medicinal plants and the extent of use would help in assessing the threat to such species. The major countries to take initiative to document medicinal plant wealth of the respective country
- The *ex situ* conservation program could be extended to herbal gardens, botanic gardens and arboreta, medicinal plant gardens, nurseries and gene banks. The *ex situ* conservation of threatened and endangered species of medicinal plants could be taken in priority. Tissue culture protocols for micro-propagation and *in vitro* long-term storage should also be attempted to RET species of MAP

Quality Standards

No system of medicine can achieve a high degree of credibility and mass acceptance unless some degree of quality assurance is maintained. In many countries, herbal products are marketed through health stores as dietary supplements. For quality assurance, a minimum documentation

of the product needs to be done indicating: i) that the products are manufactured by following good manufacturing practices (GMP), ii) certificate of analysis of the batch detailing the tests performed, limits, actual value recorded, and iii) minimum labeling of contents. The drugs are generally required to be labeled to comply with the label provision of the concerned country into which imported.

In Europe, there were different pharmacopoeias to define medicinal plants/extracts. European pharmacopoeia is a legal binding in EEC countries. Specific tests on quality and regulatory requirements in respect of packing, labeling, testing, fumigation and storage environment do exist for export/import of herbal medicine products.

The main difficulty in prescribing the standards for herbal medicines is due to the fact that most of the products use whole plant or extracts of parts of plants and in some cases a mixture of number of plants (polyherbal drugs). It is challenging to develop suitable standards because the preparation of the drugs based on medicinal plants is regarded as one active entity in its entirety. For herbal medicines, the qualitative and quantitative variations in the contents of bioactive phytochemicals should be considered in fixing standards and specifications. Standardization, optimization and control of growing conditions should guarantee quality controlled production of many plant derived compounds. Good agricultural practices need to be prescribed for enabling production of quality products free from pesticide residues, heavy metals and microbial contaminations.

The quality control must start with the raw materials and the next stage is the quality control during processing and manufacturing. In India, concerned nodal department have already notified elaborate good manufacturing practices. The guidelines of good agricultural and collection practices for medicinal plants documented in a publication of ICAR, IFAD and FAO, (2010) should be adhered in order to ensure quality control of raw material derived from cultivated MAP species. Drug testing laboratories engaged exclusively, for traditional herbal medicines may also play important role in ensuring quality of herbal medicines. Enforcing uniformity in processing may also reduce the variation in the quality of same product of different manufacturers.

Also, there is a need to strengthen safety evaluation centres as some herbal drugs are toxic if not properly procured and used judiciously. Safety evaluation should be mandatory before marketing for human consumption. Clinical validation for confirming efficacy of the drug by following standard protocols prescribed by WHO will help in building confidence in the minds of consumers about quality standards of plant based medicines.

In recent times, there had been some published reports of consumers suffering adverse health effects caused by poor quality herbal medicines. Quality of raw material used is often indicated as the cause of the problems. As a result, herbal medicine industry has been under pressure for quality assurance and some countries have developed / created new laws/stricter regulations both for manufacturing the medicine as well as sourcing the raw materials. The guidelines for good agricultural and collection practices (GACP) for medicinal plants developed in 2003 by the WHO aimed at improving the quality of medicinal plant material being used in the herbal medicines in the market.

Objectives of GACP Guidelines

The main objectives of GACP guidelines as stated by WHO are as follows:

- To contribute to the quality assurance of medicinal plant materials used as the source for herbal medicines to improve the quality, safety and efficacy of finished herbal products
- To guide the formulation of national and/or regional GACP guidelines and GACP monographs for medicinal plants and related standard operating procedures
- To encourage and support the sustainable cultivation and collection of medicinal plants of good quality in ways that respect and support the conservation of medicinal plants and the environment in general
- Following the publication of WHO's GACP guidelines, several countries and regions, including China and the European Union, developed their own GACP standards and guidelines. In 2009, the National Medicinal Plants Board of India (NMPB) followed suit and developed a set of standards known as good agricultural practices (GAP) and good field collection practices (GFCP) for medicinal plants.

Status of MAP production in Asia-Pacific Region

Asia has a long history of medicinal plant use in primary healthcare arrangements. Codified systems such as traditional Chinese medicine, Ayurveda, Siddha, Unani and Tibetian medicines are known to exist from time immemorial. Some of the Asian species in the wild have been utilized in modern healthcare system. Reserpine from the roots of *Rauvolfia serpentina* or paclitaxel from Himalayan yew (*Texus wallichiana*) have important pharmaceutical uses in Europe, North America and others. Due to overexploitation, some of the species in the wild are now considered as threatened / endangered and some of the countries are trying to control such trend by imposing regulatory measures. Member countries of the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) have also established international trade controls for some Asian medicinal species. Distribution and spread of many species is quite wide and the bioactive ingredients of medicinal value often varies under different agro-climate situations. Research efforts in many of the Asian species have made it possible to stabilize production base towards commercialization. Asian countries engaged in production of major medical plants as listed by Chapman and Chomchalow (2005) is attached (Table 2).

Many of the Asian species are used in more than one medicinal system. For example, *Picrorhiza kurrooa* (kutki) has been in use in Indian Ayurvedic preparations, in traditional Chinese medicine, in traditional Tibetain medicine and listed in the Hamdard Pharmacopoeia of Eastern Medicine (Qurabadain of Hamdard). Extracts of kutki is considered as one of the potential plant based pharmaceuticals for modern system.

Wild medicinal plants support livelihood of a large number of poor and underemployed work force and medicinal plants supply chain from wild collection to end market involves a complex trade chain, often crossing the borders of neighboring countries. For example, many of the Himalayan species traded from Nepal to India, provide livelihood support to many

Table 2. Production of major medicinal plants in Asia (country-wise)

Species	CPR	IND	INS	NEP	PAK	PHI	SRL	THA	VIE	Others
Aconitum carmichaeli	*									
Aloe barbadensis		**					**	**		
Alisma orientale	*									
Allium sativum	*	*	**		**			*		ROK
Amomum villosum	**									
Andrographis paniculata						**		**		
Angelica sinensis	*							**		
Areca catechu								*		
Artemisia annua	*							**	**	
Astragalus membranaceus	*									
Aulandia lappa	*									
Atractylodes macrocephala	*									
Atropa belladonna		**		**	**					
Cassia angustifolia		*						**		
Catharanthus roseus	*									
Chrysanthemum cinerariefolium		*		**	**					
Chrysanthemum morifolium	*							**		
Cinchona ledgeriana		**	**							
Clinanthus nutans								**		
Codonopsis pilosula	*									
Coptis chinensis	*									
Cornus officinalis	**									
Corydalis yanhusuo	**									
Croton sublyrata								**		
Curcuma domestica		*	*		**		**	*		
Dendranthema morifolium	*									
Dioscorea deltoidea		**								
Dioscorea floribunda		*								
Dioscorea opposita	*									
Dioscorea vomitoria		**								
Ganoderma lucidum	*							**		
Glycyrrhiza glabra	*									

Contd...

Table 2 (contd...)

Species	CPR	IND	INS	NEP	PAK	PHI	SRL	THA	VIE	Others
lsatis indigotica	*									
Lycium barbarum	*									
Magnolia officinalis	*									
Morinda officinalis	**									
Ophiopogon japonicus	*									
Panax ginseng	*									ROK
Panax notoginseng	*									
Panax quinquefolia	*									ROK
Panax vietnamensis									**	
Papaver somniferum		*								
Piper betel							**	*		
Piper nigrum		*	*				**	**		MAL
Plantago ovata		*			*					
Pogostemon cablin	**	*								MAL
Rauvolfia serpentina		*		*			**			
Solanum viarum		*								
Swetia chirata				*	*					
Syzygium aromaticum		*	*				*			MAL
Tinospora crispa		*				**				
Trichosanthes palmatum				*						
Valeriana wallichii				**	**					
Vitex negundo							**			MAL, PHI
Zingiber officinalis	*	*	**		**	*	*			MAL, ROK

CPR: China; IND: India; INS: Indonesia; MAL: Malaysia; NEP: Nepal; PAK: Pakistan; PHI: Philippines; ROK: Republic of Korea; SRL: Sri Lanka; THA: Thailand; VIE: Vietnam.

*major producer; **minor producer

Source: Chapman et al., 2005

rural households in the tribal areas of both the countries. Asia's medicinal plants thus play an important role in income generation of a section of population.

In Asia, only a few countries, mainly China, India, Indonesia, Nepal, Thailand and Vietnam produce medicinal and aromatic plants commercially. A few other countries such as Bangladesh, Pakistan produce MAP in small scale mostly for domestic use. China and India are the world's leading exporters of medicinal and aromatic plants followed by Bhutan, Lao PDR, Nepal and to a lesser extent Bangladesh. China, India, Indonesia and Pakistan maintain considerable natural

forest cover and still allow collecting these plants from the wild. A few countries, including China, India and Sri Lanka have formulated legislation to conserve the diversity of medicinal and aromatic plants.

Many of the important Asian spices have ethnomedical uses. Extracts of spices are used as infusions, decoctions, macerations, tinctures, fluid extracts, teas, juices, syrups, poultices, compresses, oils, ointments and powders. Some common spices having ethnomedical and neutraceutical values are given in Table 3.

Table 3. Important spices for ethnomdical and neutracutical use

Spices	**Important chemical components/ingredients**	**Medicinal value**
Black pepper	Piperine, S-3-Carene, B-caryophyllene	Dried powder used for curing urinogenital complaints, analgesic and antipyretic
Turmeric	Turmerone, Zingeberene, 1, 8-Cineole	Treating sprains, analgesic, stomach pain cure, skin health; antioxidant properties
Ginger	Gingerol, Shogaol, geranial	Rhizome used as digestive, carminative and anti-asthmatic, anti-inflammatory activity
Fennel	(E) anethole, fenchone	Leaf infusions for stomach ailments, remedy to vomiting
All spices	Eugenol, B-caryophyllene	Toothache cure, Carminative

There are scanty reports on current herbal medicine system prevailing in the Southwest and Southeast Asian regions. In the Middle East, traditional medicines still play a major role in healthcare system, despite the availability of modern medicines. Traditional medicines in Iraq are known and used in folk medicines. Medicinal plants are also used in the form of beverage, prepared by soaking either the leaves or whole plant in boiling water (Sabra and Walter, 2000). Some of the medicinal and aromatic plants in use for herbal medicine preparations in Iraq are - *Cyperus alopecuroids* Rottb., *Cyperus pygmaeus* Rottb., *Rubus sanctus* Schreb. Iraq is one of the leading world producers of liquorice obtained from the dried roots and rhizomes of *Glycyrrhiza* spp. particularly *G. glabra* which grows abundantly in the wild.

Herbal medicines are in use in many of the Southeast Asian countries, namely, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. Southeast Asia is the home of extensive tropical rainforest, apart from Central and South America. Malaysia is among the world's top 12 biodiversity rich countries where traditional medicine system links Ayurveda, Siddha, Chinese medicines, traditional Malony medicines, Unani and others.

The list of medicinal plants which are cultivated on commercial scale in Asian countries (Table 4) and list of medicinal plants collected from wild in some of Asian countries (Table 5) adapted from Chapman and Chomchalow (2005) amply show the rich medicinal plant diversity and their use mainly in primary healthcare area in good number of Asian countries. Details of production and trade scenario of some of the important countries in Asia are described separately.

Table 4. Medicinal plants cultivated on commercial scale in Asia

Species	Common name	Parts used	Species	Common name	Parts used
Aconitum napellus	Aconitum	Root	*Isatis indigotica*	Ta ching Yeh	Leaf, root
Adhatoda vasica	Vasaka	Leaf	*Kaempferia galanga*	Kencur	Rhizome
Alisma orientale	Tsettsieh	Rhizome	*Lonicera japonica*	Honeysuckle	Flower
Allium domesticum	Garlic	Bulb	*Lycium barbarum*	Kou Chi Tzu	Fruit
Aloe barbadensis	Aloe vera	Flower	*Magnolia officinalis*	Hon Po	Bark
Ammi majus	Ammi	Fruit	*Matricaria chamomile*	Chamomile	
Andrographis paniculata	Fa Thali Chon	Aerial parts	*Memha ovensis* var. *piperascens*	Japanese mint	Aerial parts
Angelica gigas	Korean angelica	Root	*Morinda officinalis*	Pa Chi Tien	Root
Areca catechu	Arecanut	Fruit	*Ophiopogon japonicum*	Mai Tung	Root
Angelica acutiloba	Duong Qui		*Paeonia lactiflora*	Chinese peony	Root
Artemisia annua	Qing Hao	Aerial parts	*Panax ginseng*	Ginseng	Root
Astragalus membranaceus	Huang Chi	Root	*Panax notoginseng*	Ginseng	Root
Atractylodes macrocephala	Atractylodes	Rhizome	*Panax pseudoginseng*	Ginseng	Root
Atropa belladonna	Belladonna	Berry, leaf, root	*Panax quinquefolia*	American ginseng	Root
Baleriana lupilina	Salet Phangphon	Aerial parts	*Panax vietnamensis*	Vietnamese ginseng	Root
Cassia angustifolia	Senna	Pod, leaf	*Papaver somniferum*	Opium poppy	Latex
Catharanthus roseus	Periwinkle	Root	*Philodendron chinense*	Huang Pai	Bark
Cephaelis ipecacuanha	Ipecac	Root, rhizome	*Piper betel*	Betel pepper	Leaf
Chrysanthemum cinerariifolium	Pyrethum	Flower	*Piper nigrum*	Black pepper	Bark
C. *morifolium*	Kek Huai	Flower	*Piper retrofractum*	Java long pepper	Fruit
Cinchona ledgeriana	Cinchona	Bark	*Plantago ovata*	Isaphgol	Seed
Cinnamomum camphora	Camphor	Berry	*Platycodon grandiflorum*	Balloon flower	Root
Claviceps purpurea	Rye ergot	Sclerotium	*Rauvoljia serpentina*	Rauwolfia	Root
Clinacanthus nutans	Phaya Yo	Aerial parts	*Solanum khasianum*	Solanum	Fruit

Contd...

Table 4 (contd...)

Species	Common name	Parts used	Species	Common name	Parts used
Coptis chinensis	Huang Lien	Rhizome	*Solanum laciniatum*	Solanum	Fruit
Comus officinalis	Shan Chu Yu	Fruit	*Solanum trilobatum*	Mawaeng	Fruit
Corydalis yanhusua	Yen Hu Suo	Rhizome	*Solanum viarum*	Steroid solanum	Fruit
Costus speciosus	Crape ginger	Rhizome	*Swertia chirata*	Chirat, Chiretta	Aerial parts
Croton sublyratus	Plan Noi	Seed	*Syzygium aromaticum*	Clove	Flower, bud
Curcuma domestica	Tunneric	Rhizome	*Tinospora cardifolia*	Giloy	Stem
Cymbopogon winteriamus	Citronella	Aerial parts	*Trichosanthas bracteata*	Indreni	Fruit, root
Dendranthema morifolium	Chu Hua	Flower	*Valeriana jatamansi*	Indian valerian	Rhizome, root
Dioscorea deltoidea	Medicinal yam	Fruiting body	*Valeriana officinalis*	Valerian	Rhizome, root
Dioscorea opposita	Medicinal yam	Fruiting body	*Vilex negundo*	Five-leafed chaste tree	
Dioscorea vomitoria	Medicinal yam	Fruiting body	*Withania somnifera*	Asgand	Root, leaf
Geranium nepalense	Geranium	Fruiting body	*Zingiber purpureum*	Phlai	Rhizome
Ganoderma luidum	Lingzhi	Fruiting body	*Zingiber officinalis*	Ginger	Rhizome
Hibiscus sabdarifa	Roselle	Aerial parts			

Table 5. Medicinal plants collected from the wild in Asia

Species	Common name	Family	Parts used	Country of collection
Aesculus indica	Indian horse chestnut	Sapindaceae	Seed	PAK
Alocasia macrorrhiza	Shott giant taro	Araceae	Rhizome	LAO, VIE
Alstonia scholaris	Dita bark	Apocynaceae	Cortex	LAO, VIE
Amomum	Cardamom	Zingiberaceae	Fruit	LAO, VIE
Amorphophallus rivieri	Konjac	Araceae	Tuber	LAO, VIE
Artemisia maritima	Wormseed	Compositae	Aerial parts	PAK, VIE
Artocarpus lakoocha	Monkey jack	Moraceae	Lignin	LAO, VIE
Blumea balsamifera	–	Compositae	Leave	LAO, VIE
Catharanthus roseus	Periwinkle	Apocynaceae	Root and leaf	LAO, VIE
Cassia alata	Ringworm bush	Leguminosae	Leave	PHI, VIE

Contd...

Table 5 (contd...)

Species	Common name	Family	Parts used	Country of collection
Cinchona ledgeriana	Cinchona	Rubiaceae	Bark	LAO, VIE
Coscinium usitatum	–	Menispermaceae	Creeper	LAO, VIE
Costus speciosus	–	Zingiberaceae	Rhizome	LAO, VIE
Dioscorea deltoidea	Steroidal yam	Dioscoraceae	Tuber	PAK, VIE
Drymaria fortune	–	Caryophyllaceae	Rhizome	LAO, VIE
Embelia ribes	–	Euphorbiaceae	Fruit	LAO, VIE
Ephedra gerardiana	–	Gnetaceae	Berry	PAK
Glycyrrhiza glabra	Licorice	Leguminosae	Root and rhizome	PAK, CPR
Kaempferia galanga	Galangal	Zingiberaceae	Rhizome	LAO, VIE
Lagerstroemia speciosa	Banaba	Lythraceae	Leaf and bark	PHI, VIE
Leonurus heterophyllus	–	Labiatae	Herb	LAO, VIE
Moringa oleifera	Drumstick tree	Moringaceae	Seed	PHI, VIE
Rauvolfia serpentina	Rauwolfia	Apocynaceae	Root	IND. NEP. LAO. THA. VIE
Schejjlera elliptica	–	Araliaceae	Bark	LAO, VIE
Smilax glabra	–	Liliaceae	Rhizome	LAO, VIE
Stephania rotunda	–	Minispermaceae	Tuber	LAO, VIE
Sterculia lygnophora	–	Steculiaceae	Fruit	LAO
Styrax tonkinensis	–	Styracaceae	Resin	LAO, VIE
Swietenia macrophylla	Mexican mahogany tree	Meliaceae	Seed	PHI
Vitex negundo	Five-leafed chaste tree	Verbenaceae	Leaf	PHI, VIE
Xanthium strumarium	Cocklebur	Compositae	Fruit	LAO, VIE

CPR: China; IND: India; LAO: Laos; NEP: Nepal; PAK: Pakistan; PHI: Philippines; VIE: Vietnam; THA: Thailand

Major MAP Growing Countries in Asia

China

Genetic resources

China has rich genetic recourses and a great variety of medicinal plants. It is reported that there are 12,807 kinds of Chinese medicines, out of which about 11,146 (80%) are of plant origin. In general, 320 medicinal plants are the most commonly used. China's annual herbal drug production is reported to be around US $ 48 billion with export of about US $ 3.6 billion (Sangita Kumari *et al.*, 2011). Japan, Hong Kong, Korea, and Singapore are the major importers of herbal drugs making 66 per cent share of China's botanical drug exports.

The ethnic groups in China, namely, Han, Zang, Meng, Wei and Dai have traditionally utilized Chinese medicines. According to statistics, 3,781 ethnic medicines are in use among the 25 minority nationalities in Yunnan Province alone (http://english.biodiv.govt.or/images-biodiv/resources/medicineal-en.htm)

Medicinal plants resources diversity

- There are 7,137 medicinal plants in China at present according to Xin Hua compendium of Metaria Medica (Source: Jiangsu Institute of Botany, 1988-91) of which 492 species are cultivated.
- Great diversity of cultivated species and strains exists and a good number of varieties of medicinal plants have been developed locally. For example, *Panax ginseng* has many local cultivars such as, Dmaya, Ermaya Changbo, Yuanbang and Yuanly.
- There are abundant wild relatives of cultivated plants. For example, the cultivated *Panax ginseng* has many wild species, e.g. *Panax stipuleanthus*, *Pijaponica* var. major, *P. Zingibarensis*, *P. natoginseng*, *P. pseudoginseng* and others. Similarly, there are as many as 17 relatives of *Fritillaria* spp. and more than 20 of *Aconitum carmichaeli*.
- To maintain genetic diversity and to conserve genetic wealth, more than 100 botanical gardens and tree gardens have been established in different regions of China. Nevertheless, much work needs to be done to investigate China's medicinal plant resources, their *in situ* and *ex situ* protection and to reduce and eliminate anthropogenic destruction.

Major constraints and threats

- Loss of genetic resources is happening through excessive picking and digging of wild medicinal plants and many valuable species are confronted with imminent danger.
- Deforestation for cultivation and industrialization, large scale felling of forest trees resulted in wrecking of valuable medicinal plant resources.

Commercial cultivation of medicinal plants

Out of 78 medicinal plants which are cultivated on commercial scale in Asia (Table 4), China alone leads in 26 species. Out of the 5 *Panax* species, China cultivates 4 species (*Panax ginseng*, *P. natoginseng*, *P. pseudoginseng*, *P. quirquefallia*) on commercial scale and thus dominates the international market.

The medicinal plant market in China is large, and shared between public and private ownership. Ginseng roots have been covered under the Standard International Trade Classification (SITC) Code (292.42) and Commodity Code (1211.20) numbers. EU import of ginseng goods from China in 2002 was as high as US $ 8.7 million. Area of medicinal crops in China during 1990-2001 has been shown as 8,27,000 hectares. (Source: Trade in Medicinal Plants, Commodities and Trade Division: Economic and Social Department of FAO, Rome, 2005).

The Traditional Chinese Medicine (TCM) tends to use the roots of plants, which are the difficult plant parts to harvest sustainably. Destructive harvesting of whole plant with roots removed resultd in extinction of certain species. This necessitated development of micro-propagation protocols for mass production of quality planting materials for commercial cultivation. Over time, TCM has developed a theory of geo-verbalism which has been used in the evaluation of efficacy, quality and safety, making TCM well known in the world. China has successfully promoted its own therapies in the world with science based principle. Growing popularity of TCM can be evidenced by the rapid increase in the number of licensed Chinese medicine providers. From June, 2003, China

introduced good agricultural practices (GAP) from Europe and by now GAP plantations of more than 30 medicinal species (e.g. ginseng, peony, liquorices, agelica) have been established.

Among the medicinal plants, the Asian ginseng (*Panax ginseng*) occupied very high position in the market share. The roots are regarded as a tonic with anti-stress, anti-fatigue and anti-aging properties. Although *Panax ginseng* is widely cultivated and most of the commodities in trade are sourced from cultivation, harvesting from wild still takes place. Originally, *P. ginseng* was mainly distributed in northeastern China, Korea and parts of east Russia, due to loss of genetic diversity in China, main area of the species now lies in Russian Far East (Lange, 2004).

The Chinese Government has pledged to create several export-oriented TCM giants in the country. It is reported that hospitals practicing TCM treat more than 200 million outpatients and almost 3 million inpatients annually (Patwardhan *et al.*, 2005). About 95 per cent of general hospitals in China have traditional medicine departments. Selective incorporation of elements of TCM alongside the modern methods of diagnosis has helped in achieving success in botanical medicine promotion in China.

India

Genetic resources

In India, about 8,000 species are medicinal out of which 2,500 species provide raw materials for herbal pharmaceuticals, which are collected mainly from the wild. Out of the classified systems, Ayurveda uses 900 species, Sidha 800 species, Unani 700 species and Amchi 300 species, with certain degree of overlaps with regard to the number of species used in each system. Of the 2,500 species considered to be important source of medicinal or therapeutic components, 750 species form the ingredients of 14,000 published recipes of Ayurveda, Sidha and Unani medicines. Among the 32 most prioritized medicinal plants having commercial / industrial potential and identified by the Government of India for developmental work, 21 species are known to occur in the North Eastern Himalayan region of India.

The medicinal and aromatic plants identified for integrated development, are being investigated for their medicinal value (both traditional as well as western medicines), functional foods (for heart health, gut health, bone health and immune functions) and cosmaceutical use (skin health and beauty, transversal system of nutrient delivery). Out of 8,000 plant species, more than 1,000 are reported to enjoy commercial trade potential as botanical raw drugs.

The 2004 IUCN Red List (endangered threatened species) included 297 plant species (angiosperms and gymnosperms) in India, of which 16 are medicinal plants. Some of the threatened species are *Aconitum ferox*, *Picrorhiza kurroa*, *Nardostachys grandiflora*, *Panax pseudo-ginseng*, *Coptis teeta*, *Dioscorea deltoidea*, and *Costus sp*.

For large scale cultivation of high value medicinal plants, only 5 species, namely, *Aloe barbadensis*, *Cassia angustifolia*, *Lowsoria inermis*, *Plantago ovata* and *Trachyspermum ammi* are obtained entirely from cultivation. Raw materials of about 54 top traded medicinal plant species are collected entirely from the wild. The Ministry of Environment and Forests (MoEF) of the Government of India has banned the trade and export of 29 rare, endangered and threatened (RET) species and notified them in the negative list of export.

Several improved varieties of different medicinal and aromatic plants have been released under the all India Coordinated Research Project on Medicinal and Aromatic Plants Research (AICRP-MAPR) of the ICAR (Table 6).

Table 6. Improved varieties of medicinal plants released by ICAR (India)

Name of species	Variety	Center where developed	Year of release
C. *martinii var. motia* (Palmarosa)	Rosha Grass-49	Hisar	1989
C. *martinii var. motia* (Palmarosa)	CI-80-68	Indore	-
Cassia angustifolia (Senna)	Anand Late Selection	Anand	1989
Cymbopogon flexuosus (Lemon grass)	NLG-84	Faizabad	1994
Diascoria floribunda	FB(C)-1	Bangalore	1974
Diascoria floribunda	Arka Upakar	Bangalore	1980
Digitalis lanata (Foxglove)	D 76	Solan	1991
Glaucium flavum (Yellow horned poppy)	H47-3	Solan	1991
Glycyrrhiza glabra (Liquorice)	Haryana Mulhatti-1	Hisar	1989
Hyoscyamus muticus (Egyptian henbane)	HMI-80-1	Indore	-
Jasminum grandiflorum (Jasmine)	Arka Surabhi	Bangalore	1993
Mentha spicata (Spearmint)	Punjab Spearmint-1	Solan	1991
Papaver somniferum (Opium poppy)	Jawahar Aphim 16	Mandsur	1984
Papaver somniferum (Opium poppy)	Kirtiman	Faizabad	1990
Papaver somniferum (Opium poppy)	Jawahar Opium 539	Mandsur	1997
Papaver somniferum (Opium poppy)	Jawahar Opium 540	Mandsur	1998
Papaver somniferum (Opium poppy)	Chetak Aphim	Udaipur	1994
Papaver somniferum (Opium poppy)	Trisna	Delhi	-
Piper longum (Long Pepper)	Viswam	Trichur	1996
Plantago ovata (Isabgol)	Gujarat Isabgol- 1	Anand	1976
Plantago ovata (Isabgol)	Gujarat Isabgol-2	Anand	1983
Plantago ovata (Isabgol)	Haryana Isabgol-5	Hisar	1989
Plantago ovata (Isabgol)	Jawahar Isabgol-4	Mandsur	1996
Rauvolfia serpentina (Sarpagandha)	RI-1	Indore	-
Solanum laciniatum	NH 88-12	Solan	1991
Solanum viarum (Khasi kateri)	Arka Sanjeevani	Bangalore	1989
Solanum viarum (Khasi kateri)	Arka Mahima	Bangalore	1992
Valeriana jatamansi (Mushakbala)	Dalhousi Clone	Solan	1994
Vetivera zizanioides (Vetiver)	Hyb-8	Delhi	-
Withania somnifera (Aswagandha)	Jawahar Asgand-20	Mandsur	1989
Withania somnifera (Aswagandha)	Jawahar Asgand-134	Mandsur	1998

Source: Maiti, S. 2004

Medicinal plants promotion and support system

Institutional support for promotion of medicinal plants in India received a boost when Government of India created a separate department for Indian Systems of Medicine and Homoeopathy (ISMH), now known as AYUSH (Ayurveda, Yoga, Unani, Siddha and Homoeopathy). It was established in March 1995 to promote traditional medicine systems. Priorities include education, standardization of drugs, and enhancement of availability of raw materials, R&D, information, communication and greater involvement in the national system for addressing healthcare. A strong R&D support involving Indian Council of Agricultural Research (ICAR), Council of Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT), Botanical Survey of India (BSI), Forest Research Institute (FRI), and Ayurveda University was provided for promoting a modern medicinal plant based system utilizing mostly native species.

India has world class expertise and facilities for biological screening, toxicological testing and improved agro-technology for cultivation of medicinal plants. The R&D establishments are involved in standard-design of the herbal medicines and active compounds in the formulations. Reserpine (antihypertensive from *Ravollfia* spp.) is an extremely valuable contribution from Ayurvedic system.

Ayurvedic preparations have been successfully evaluated for treatment of bronchial asthma, rheumatoid arthritis and ischemic heart disease. Standardization fraction of gugulipid from *Commiphora wighti* developed by the Central Drug Research Institute (CDRI) of Govt. of India has already been marketed (Guglip, Cipla Ltd.) for treating hyperlipidemia and atheriosclerosis. Many such botanical drugs are in use and under the process of release. The Ayurvedic Pharmacopoeia of India includes monographs of 258 different Ayurvedic drugs.

The Indian Drug Manufacturers Association has published Indian Herbal Pharmacopoeia with monographs on widely used medicinal plants growing in India, where scientific data have been provided. India, however, needs improvement in enforcing quality standards of raw drugs and ISM products. Also, good agricultural practices based cultivation needs greater push. Strong database on production, utilization and supply of medicinal plants should also be flagged as a focused activity.

According to assessment of Foundation for Revitalization of Local Health Traditions (FRLHT), India, 216 high priority medicinal plant species of India have been identified for study and promotion for medicinal use.

Nutraceuticals / functional food and perfumery / aroma chemicals from natural sources are the fastest growing sectors in the global market of medicines. It is reported that there are more than 250 companies both national and international that are selling more that 1,000 botanical products with a claim to cure or manage various diseases like obesity, arthritis, diabetes, aging, impotence, high blood pressure, etc. Collaborative approach combining public funded R&D institutions and drug manufacturers like Dabur, Zhandu, Baidyanath, Kottakal Arya Vaidysala and others are needed. Herbal drug development program for developing effective herbal remedies focusing on a few major and common diseases like hepatic disorder, arthritis and diabetes should be given priority.

New technologies are being constantly developed to isolate and identify the actual bioactive compounds of medicinal plants. Continuous search to isolate chemical constituently/ drug molecules

for anti-cancer activity of natural herbs is very important. Published literature show that some species, namely, *Moringa oleifera*, *Calotropis procara*, *Tephrosia purpura*, etc. have the potential anti-cancer activity. Some case extracts are shown to be more potent than pure component. Such possibilities need to be ascertained more vigorously so as to develop the extract for use as drug. There is a need to focus more on research publications related to quality, safety and efficacy of herbal medicine development in India.

Demand, supply and trade of MAP

Under Indian System of Medicine (ISM), about 9,500 herbal industries of various capacities have been registered. For manufacture of herbal medicine formulations, large quantity of medicinal plants derived raw materials are needed. It is estimated that annual demand for raw materials during 2005-06 was around 0.32 million tons (dry weight basis) out of which approximately 0.18 million tons were utilized by the herbal industry and remaining 86,000 tons and 5,600 tons were utilized in rural households and exports, respectively.

Out of botanical medicine species, the fruits of perennial tree species 'amla' (*Emblica officinalis*) stands first, being the highest consumed botanical raw drug by Indian herbal industry. In the export front, isabgol husk (*Plantago ovata*), senna leaves and pods; henna leaves and myrobalans account for about 70 per cent of total export by volume. Major export items are (i) medicinal plants, including herbal (ii) extracts including essential oils, and (iii) gums and resins. In 2011, India's total export value of traditional medicinal products is reported to be US$ 2437.38 million. (Source: Inter. Conference on Traditional Medicine for South East Asian Countries, 12-14 February, 2013, New Delhi).

Future growth and institutional support

There is a need to streamline the following strategic areas:

- Consolidation of species-wise data in respect of raw materials collected from wild (forest area), cultivation and imports
- Marketing has been the major bottlenecks in the growth of MAP sector in the past. Models of value chains starting from right genotypes, good agronomy, processing, value addition and marketing need to be in place.
- High priority needs to be accorded to *in situ* conservation as well as resource augmentation of MAP species of high consumption and in high volume trade. Appropriate management interventions for building up populations of such species to be worked out.
- Capacity building and knowledge upgradation, provision of export incentives and import restrictions are essential.
- Good agricultural and collection practices (GACP) need to be encouraged and made mandatory for MAP and existing systems of coding botanicals in foreign trade (HS Code) needs review/ improvement.
- Drug discovery research from native botanical species needs focused attention involving modern molecular biologists, phytochemists and ecologists. Incorporation of elements of TM alongwith modern methods of diagnosis with science based approval will open up vast market in advanced countries.

Bangladesh

MAP production and trade status

The Government of Bangladesh has an active policy of promoting increased use of herbal medicine in primary healthcare sector. Medicinal plant sector is almost a virgin area in terms of production interventions. About 90 per cent of locally supplied herbs are wild harvested and only 10 per cent coming from cultivation. In Bangladesh, 546 species have been identified as having medicinal properties and therapeutic use. It is reported that out of 546 species, 257 species are effective in controlling some diseases.

In Bangladesh, a number of agencies are involved in the herbal medicine sector. Department of Drug Administration of Govt. of Bangladesh is responsible for the certification and supervision of herbal medicine processors. The National Herbarium is charged with the responsibility of surveying medicinal plant genetic resources and their conservation, particularly of the endangered / threatened species. The Bangladesh Council of Scientific and Industrial Research (BCSIR) is responsible for technology development towards drug development, while the Bangladesh Forest Research Institute (BFRI) is to undertake promotional research. The national Ayurvedic and Unani Boards are responsible for items related to education in traditional medicines (TM). Medicinal Plants and Herbal Products Business Promotion Council (MPHP-BPC) promotes herbal medicine business. On the education side, there exist (i) one degree college and 13 diploma colleges for Unani system (ii) one degree college and 7 diploma colleges for Ayurvedic system. Already there are over 400 Ayurvedic and 325 Unani graduate doctors practicing herbal medicines.

Although Bangladesh is yet to develop an effective strategy for sustainable use of medicinal plants, the need of research and promotion of herbal medicines have been duly recognized and incorporated as one of the main objectives of Bangladesh National Food and Nutrition Policy (1977). The practice of systematic industrial scale use of medicinal plants is presently restricted to a few species only, namely, vasak (*Adhatoda vasica*), ashwaghandha (*Withania somnifera*), tulsi (*Ocimum sanctum*), ghritakumari (*Aloe indica*) and kalmegh (*Andrographis paniculata*). Initiatives of Swiss Agency for Development and Cooperation (SDC) for promotion of some medicinal plants cultivation in 6 northwest districts (Bogra, Gaibanda, Joypurhat, Naogaon, Sirajong, Rangpur) paid good dividends. Herbal producers normally sell their produce of vasak, ashawaghanda and kalmegh to herbal medicine manufacturing companies, namely ACME, SQUARE, Hamdard, Peptone, BN Laboratories. Tulsi products are sold to M/s. Kazi and Kazi Company involved in organic tea promotion. Sample surveys clearly show that there is a big gap between demand and supply for which the only way-out is to encourage growing of medicinal plants as medicinal crops, by following good agricultural practices (GAP) guidelines.

Market size and demand projections

A study on 'Medicinal Plants Marketing in Bangladesh' sponsored by SEDF and Inter Cooperation (IC) of SDC conducted in October, 2003, reviewed current status and estimated size of the market for processed herbal medicines in Bangladesh. The SEDF / IC study estimated the turnover figures at trade prices for Ayurvedic sector at around BDT 1,000 million, Unani at around BDT 1,800 million and Homeopathy at around BDT 500 million. According to this study, the Bangladesh herbal medicine market has been growing at over 10 per cent per annum, exceeding the allopathic sector.

The study also attempted to estimate the quantity and value of medicinal plants used as raw materials both in organized sector (large companies, small companies), unorganized sector (herbal doctors/ practitioners) and self treatments. It is estimated that around BDT 800 million (US$ 14 million) are spent annually on approximately 17,500 tons of medicinal plant (mostly dry) material.

In terms of volume, about 70 per cent of the medicinal plants used as raw material (over 12,500 tons) come from local Bangladeshi source and the remaining part is imported. In terms of value, however, the medicinal plant material grown in Bangladesh accounts for 40 per cent only, thus reflecting the need of enhanced production, product diversification as well as quality assurance of the locally grown medicinal plants. The large 20 herbal medicine processing companies of Bangladesh utilize about 25 per cent of raw material (950 tons imported and 4,500 tons of domestic produce) demand, whereas another 400 smaller processing companies accounts for 30 per cent of the demand (1,150 tons imported and 4,900 tons domestic produce). It is further reported that raw material demand is likely to increase by another BDT 300 million over next 5 years and over 50 per cent of this growth is likely to occur with major processing companies. The total value of medicinal plants during 2003 was estimated at only BDT 1,100 million (US$ 14 million).

The SEDF/IC study report suggested the following few steps for desired sustainability and further growth of herbal medicinal industry in Bangladesh: i) improvement of quality of produce; ii) commercial production of selected species; iii) market oriented production; and iv) closer linkages between producers and processors.

Growth potential of medicinal plants

Local production and supply of medicinal plants can be increased considerably by promoting cultivation of medicinal plants on commercial scale and particularly those plant species currently imported from other countries. The list of 15 most important medicinal plants in terms of value (each approximately BDT 10 million and above) as summarized from SEDF / IC report is given in the Table 7.

Of the 15 crops in good demand, two crops, namely, chirata and isabgol need specific agroclimate not easily available in Bangladesh. Most of the remaining crops can be cultivated in selected areas (Northwest, Chittagong Hills, Madhupur, Mymensing, Tangail, etc.) of Bangladesh. It was estimated that about 5,000 tons of medicinal plants valued at BDT 480 million (US $ 8 million) were imported and of the local collection around 90 per cent are collected from the wild. The tree species like amloki, haritaki, bahera, bael, arjun etc. are mainly in the homesteads / forest, whereas short gestation crops like ghritakumari (*Aloe indica*) is cultivated in Natore, ashwagandha (*Withania somnifera*) is grown in Chapai Nowabgonj, and ginger in Khagrachari of CHT and Nilphamary in the North West.

Challenges in developing TM sector

To maximize the potential of medicinal plant based traditional medicine sector, a number of issues, identified by WHO, namely, policy, safety, efficacy and quality, access, and rational use need to be addressed. The details of analysis of current status are as follows:

***Policy support*:** The role to TM in national healthcare system has been well recognized in Bangladesh. Efforts to include Unani and Ayurvedic medicines along with Allopathic medicines

Table 7. Most important medicinal plant species in terms of value

S. No.	Plant species	Quantity (tons)	Value BDT million	Growth potential
1.	Chirata (*Swertia chirata*)	201.00	100.5	Low, 100% imported
2.	Isabgol (*Plantago ovata*)	800.00	100.0	Low, 100% imported
3.	Amloki (*Emblica officinalis*)	1361.00	68.0	Good
4.	Ginger (*Zingiber officinalis*)	563.00	31.0	Very good
5.	Ashwaganda (*Withania somnifera*)	244.00	29.3	Good
6.	Join (*Trychyspermum ammi*)	647.00	22.6	Good
7.	Peepul (*Piper longum*)	126.00	13.8	Good
8.	Bael shoot (*Aegle marmelos*)	434.00	13.3	Very good
9.	Methi (*Trigonella foenumgraecum*)	270.00	13.4	Good
10.	Mutha (*Cyperus rotundus*)	416.00	12.5	Very good
11.	Tokma (*Hyptis suaveolens*)	300.00	12.0	Good
12.	Vasak (*Adhatoda vasica*)	261.00	11.7	Very good
13.	Ghritakumari (*Aloe indica*)	1000.0	10.0	Very good
14.	Arjun (*Terminalia arjuna*)	330.00	9.9	Very good
15.	Haritaki (*Terminalia chebula*)	835.00	9.4	Very good

Source: SEDF / IC, 2003

under healthcare program, strengthening of human resource development (HRD) activities in traditional medicine sector, establishment of over 400 herbal medicine processing companies need policy support. The growth of Unani medicine is partly due to the fact that more number of trained Hekims are now practising Unani system. However, a policy defining a clear role of TM in national healthcare diversity, ensuring that the necessary regulatory and legal mechanisms are established for promoting and maintaining good practice must be in place. Also, the policy should ensure sufficient provision of funding for research, education and training.

***Safety, efficacy and quality*:** The medicinal plant based TM industry is modernizing, both through its own efforts and with entry of corporates. However, the raw materials of local sources are often of poor quality and imported produce receive higher price mainly due to better quality. In case of herbal medicines, effectiveness and quality depends both on biotic and abiotic factors and for understanding this research support is very essential, which is unfortunately lacking in Bangladesh. If the quality is not ensured, Bangladesh may even lose market share from its existing 40 per cent by value and companies may be tempted to use imported herbal plants/extracts. National surveillance system to monitor the quality and safety of the traditional medicines is essential.

***Access*:** It is reported that over 90 per cent of medicinal plants are sourced from the wild. As the wild harvest is unsustainable and of poor quality, it is high time to introduce improved varieties of medicinal plant species of local importance. If the access is to be increased substantially, the natural resource base upon which certain products and therapies depend must be protected.

Also, commercial scale production of well adapted medicinal plant species must be increased. The medicinal plant based industry is confident of the efficacy of its products especially for stomach ailments, male and female sexual health as well as tonic and *sharbet* drinks.

***Rational use*:** Lack of training for TM providers and allopathic practitioners and lack of information for public on rational use of traditional medicines are commonly experienced. A proper integration of TM and Allopathic systems of treatments is very essential and some of the developing countries are already attempting for a integrated system of healthcare by recognizing and incorporating TM officially under healthcare provisions.

Way forward strategic actions

Keeping in view of the challenges in developing the TM Sector and actions already taken by the Government of Bangladesh, the following strategic actions are suggested:

National policy and regulatory framework	• Streamlining of regulatory and legal mechanism • Enhancing allocation of resources for TM development and capacity building
Safety, efficacy and quality	• Strengthening research and standardization of research methodology • Creating adequate evidence-base for TM therapies and products • Building a regulation and registration system for herbal medicines • Developing a system of registration and deregistration of TM practitioners
Access	• Identifing of safe and effective therapies and products • Building a sustainable medicinal plant resource base
Rational use	• Developing regular training and communication mechanisms for TM providers and allopathic practitioners. • Publicizing TM medicines

Traditional medicine sector in Bangladesh comprising of Unani, Ayurveda and Homeopathy is largely medicinal plant based. Of the total annual raw materials requirement of medicinal plants in Bangladesh in 2003 was estimated to be around 17,000 tons of dried products and valued at BDT 800 million, about 70 per cent by volume is indigenous plant materials. Most of the plant material, however, comes from the unorganized source / wild and over exploitation resulted into unsustainability of the resource base. Inspite of 70 per cent local supply by volume, value wise it is not proportionate (estimated as 40% by value), reflecting inferior quality of the raw material. Since the actual useful ingredient content in MAP depends on varieties, post-harvest operations and processing arrangements, a great deal of care is needed for commercialization of medicinal and aromatic plants. Nevertheless, the raw material demand of medicinal plant is on the rise. Out of 15 species of medicinal plants listed excepting two (isabgol and chirata), the remaining should be profitably cultivated in Bangladesh. Similarly, in case of aromatic plants, *Cymbopogon* grass and Japanese mint (*Mentha arvensis*) are likely to be of commercial success. Policy support of the Government, strong R&D and private initiative/investment are the needs of the hour.

Nepal

Medicinal plants are important natural resources for proving healthcare as well as livelihood support for a vast majority of the rural population in Nepal. It is reported that about 80-85 per cent Nepalese population depend on traditional medicines.

Genetic resources

Nepal is rich in genetic resources. Of the estimated 7,000 vascular plants naturally occurring in the country, about 700 are considered as medicinal plants. Some of the species are well suited to high mountains with temperate climate. The continuous collection from the wild has resulted depletion of precious natural resources.

The Ministry of Forest and Soil Conservation (MFSC), Government of Nepal endorsed the development and the management of MAP as one of the six primary programmes under the Forest Sector Master Plan prepared as back as 1988. The 10th Five Year Plan (2003-2008) of GON greatly emphasized the development of high priced medicinal plants / herbs for domestication, cultivation, processing and marketing. Despite all such Governmental initiatives, the medicinal plant sector has not developed in a desired way.

Production and trade status

Many high value medicinal plants species are supplied from Nepal and some 200 species are reported to be traded (Source: http://www.ansab.org/userfile/i Domestic Market NW 041.pdf).

Nepal is an important medicinal plant exporting country. India is by far the dominant export destination and there is limited domestic demand for raw materials in Nepal for its own use. The total CIF export value was estimated at US$ 8.1 million in 1997-98. The top 5 species traded were *Nardostachys grandiflora*, *Swertia chirayita*, *Neopicrorhiza scrophulariflora*, *Zanthoxylum armatum* and *Sapindus mukorossi*; together they made up more than 50 per cent of the total value (Olsen, 2005).

Intervention areas

- Commercial gathering of selected medicinal plant species to meet increasing national and international market demand can result in overexploitation of natural genetic resource base. There is an urgent need to identify, document and conserve the medicinal plants in Nepal.
- Rare and high priced medicinal herbs need commercial cultivation by following good agricultural practices. Elite clones need to be identified, multiplied, and maintained in field gene banks.
- It is crucial to identify respective roles and responsibilities of various stake holders ranging from collectors to end users; local traders to exporters; traditional healers to profession practices, small formulators to industrial manufacturers and the government agencies.
- Pre and post-harvest produces of dominant species need to be ensured for trading quality produce to attract better price.

South - Pacific

Genetic resources

In the publication of WHO Regional Office for the Western Pacific, Manila entitled, "Medicinal Plants in the South Pacific" published in 1998, detailed information on 102 medicinal plants commonly used in the South Pacific Islands have been described. The South Pacific Countries are covered by major sub-regions, namely, (i) Melanesia, comprising of New Guinea (Papua New Guinea and Irian Jaya), the Solomon Islands, Vanuatu and Fiji, (ii) Micronesia, mostly atol nations in the Central Western Pacific, and (iii) Polynesia, including Islands of French Polynesia, Cook Islands, Tonga, Samoa and others.

Out of three sub-regions, Melanesian countries generally have more diverse flora. It is reported that in Fiji, there are about 2,500 plant species out of which about 20 per cent are used for medicinal purpose. In Fiji and part of Polynesia, the herbal remedies have been well documented. In many of the Island countries, documentation of medicinal plants is generally poor and inadequate.

Promotional status

Most of the South Pacific Islanders retain faith in the herbal medicines based treatments performed by native healers. Skin problems and wounds are commonly treated by herbal medicines. Not much initiatives have been undertaken to improve production, processing and marketing of herbal medicines in the South Pacific. Some of the 102 species described in the WHO publications are commonly used horticultural crops (*Citrus sinensis*, *C. aurantium*, *Carica papaya*, *Cocos micifera*, *Artocarpus altilis*, *Psidium guajava*, *Punica granatum*, *Colocasia esculenta*, *Curcume longa* etc.). In many countries of the world, much work has been carried out to promote some other typical MAP, namely, *Aloe vera*, *Azadiracta indica*, *Ocimum* spp, *Cassia alata* and good information, including cultivation practices, is available. R&D support to develop good agricultural and collection practices (GACP) in such species may help in commercialization of MAP in the South Pacific. *In situ* and *ex situ* conservation of native species and their detailed characterization including chemo-typing will go in a long way to preserve and use medicinal plant wealth in the South Pacific.

Areas for improvement

Medicinal plants production

The review of the current status of production and trade of medicinal plants in the diverse geographical situations, namely, (i) two large Asian countries, viz. China and India, (ii) one hilly and mountainous country, viz., Nepal, (iii) one agriculturally rich country with high cropping intensity, viz., Bangladesh, and (iv) the South Pacific region representing Island ecosystem, reveals that high biological diversity, abundant raw materials from the wild and through cultivation, rich traditional knowledge have made all these countries highly suitable for developing sustainable medicinal plant industry to support livelihood of a large section of native populations. For enhancing the growth of herbal medicine sector in the Asia – Pacific region, the following strategic actions are suggested:

- Both in China and India, botanical medicine system has received institutional support for improvement of both genetic stock and production practices. Knowledge of traditional systems of medicine (viz. Chinese system of medicine in China and Ayurvedic and Unani systems in India) contributed significantly in harmonized growth in herbal medicine sector.

Technological support in developing herbal formulations made many of the products of these two countries acceptable to developed economy countries. Strengthening of R&D in MAP is a pre-requisite for sustained development of herbal medicine industry.

- Three remaining countries represent distinct and diverse agro-climatic situations. Nepal and Bangladesh have made some beginning in herbal medicine promotion. The Government policy and private investments are keys for advancement in Bangladesh and Nepal.
- Developmental approach in medicinal plant sector greatly varies depending on the nature of end use products. Fixing standards and specifications of identity, purity and strength for traditional medicines cannot be the same for similar parameters of modern manufactured medicines. Concept and theory of traditional medicine systems being quite different, quality standards of botanical medicine will be different from the products of pharmaceutical manufactures.
- The growth of botanical medicine sector for many years developed on wild collections from natural forests. A few Asian countries (e.g. Nepal, Bhutan, Lao PDR and others) that are able to maintain high degree of forest cover are still collecting medicinal plants from the wild. Globally, raw materials for pharmaceutical manufacturers are being sourced both from the wild as well as from systematic cultivations. R&D support, has made it possible to produce quality raw materials in bulk quantity both in China and India. Good agricultural and collection practices (GACP) must be followed to develop internationally acceptable quality products out of medicinal plants. Some beginning in that direction even though in limited quantity, has been made in some other Asian Countries e.g. Herb Production and Processing Co. Ltd. (HPPCL) in Nepal and the ACME Laboratories Ltd. in Bangladesh. Cultivation of medicinal plants in non-agricultural lands are considered to be unsuitable and showed be avoided as far as possible. On the principles of GAP, cultivation needs to be encouraged, particularly where large manufacturing units are likely to operate.

Research preparedness

Current research efforts are far from sufficient and are spread too thinly over several items, topics and organizations. Product development in many Asian countries is one of the most neglected areas. Knowhow on cultivation, management, processing and utilization of large number of products is still inadequate. Research support and transferable technology development to improve production, utilization and processing are priority research agenda. Major actionable research areas suggested are:

- Technology for collection and production remains traditional, while processing and trade are more systematized, largely due to private sector initiatives. In countries like, China, India, Indonesia and Sri Lanka, there have been significant private sector efforts to develop processing of medicinal plants. In India, the organizations like the Foundation for Revitalization of Local Health Traditions (FRLHT) form important non-governmental efforts to strengthen medicinal plant research. Similar approach may be considered by some other countries.
- Erosion of genetic resources of MAP has been a long time concern. Ethnobotanical studies (including molecular taxonomy, distribution, economic significance, etc.) and crop improvement for developing improved varieties with increased high quality bioactive compounds recovery are important.
- The interest in plant derived aroma compounds and functional foods, is increasing tremendously. Natural isolates of some MAP species will draw increasing attention. For

development of technologies that allow faster extraction, fractionation and isolation through application of modern biotechnological tools may be more appropriate/relevant.

- Research efforts towards medicinal plant drug discovery to provide new and therapeutically significant leads against various pharmacological targets including cancer, HIV/AIDS, alzheimer, diabetes, arthritis, bronchial asthma, etc. require strong institutional and funding support. State-of-the art bioactivity screening technologies are necessary to screen *in-vitro* bioactivity of plant extracts.
- The following research topics in phytomedicine research suggested by Handa (2013) need immediate consideration
  - The high-tech methods for chemical analysis of plant extracts and standardization
  - The search for bioactive botanical constituents and their use as templates to develop new drug for diseases which at present cannot be effectively treated
  - The integration of new molecular biology methods into screening of plant extracts and their constituents
  - The good clinical practice (GCP) confirming studies on the efficacy proof and bioavailability of standardized plant extracts

Asian Network on MAP

Earlier in the Regional Expert Consultation on "Breeding and Improvement of Medicinal and Aromatic Plants in Asia" held at the FAO – RAP, Bangkok, the need to establish a Regional Network for R&D of MAP was considered. Since medicinal plant research in many of the developing countries of Asia is not well developed, a strong research network focusing production and processing aspects will boost the growth of this important sub-sector. The Asia-Pacific Association of Agricultural Research Institutions (APAARI) may take up the facilitation role for linkage among concerned national institutions and international agencies. Development of technologies to improve production, utilization and processing will be the main research agenda of this Network. A mechanism to overcome barriers to technology transfer, also need to be devised. Access of a researcher to all scientific and technological information also need to be ensured through this Network.

Conclusion

There is a clear industrial demand of MAP, owing to the increased production of botanical healthcare formulations, herbal based cosmetic products and nutritional supplements. In addition, healthcare practice of traditional healers and utilization at household level, have ensured sustained demand of medicinal products. Due to overexploitation, many of the valuable species are becoming rare and endangered. Interventions and strategic actions of biodiversity conservation as well as domestication by following good agricultural practices are essential. For a harmoridized development, effective use of tremendous rich knowledge for healthcare practices and medicinal plant drug discovery based on therapeutically significant leads need to be nurtured carefully. Several technological advances have taken place in extraction, fractionation and isolation which has earlier been the weakest segments in the pharma-industry and public research establishments in vast majority of Asian countries. Experience sharing and information access among the Asia-Pacific countries should be possible by establishing a Regional Research Network on MAP.

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Status of Utilization and Marketing of Medicinal Plants in Asia

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Introduction

It is well known that the modern chemical based medicine has evolved from use of natural materials, mainly plants for maintenance of health. A medicinal plant may be defined as a plant part having medicinal properties. The estimate of number of medicinal plants used world over is about 70,000. Traditional medicine has firm roots in India and China. These two countries account for about 40 per cent of medicinal plants use (Tiwari, 2000). Trade of medicinal plants is known to exist as early as 1st Century AD (Gairola, 2000). Items like guggulu (*Commiphora wightii*), jatamansi (*Nardostachys jatamansi*), daruharidra (*Berberis aristata*), kushtha (*Sausurea lappa*), karpoora (*Cinnamomum camphora*), haritaki (*Terminalia chebula*), bibhitaka (*Terminalia belerica*), devadaru (*Cedrus deodara*), agaru (*Aquilaria agallocha*) and tagara (*Valeriana wallichii*) were traded between India, China and other countries (Gairola, 2000). Today, the world trade in medicinal plants has reached a value of US $ 7,001.35 million (Anonymous, 2011a). It is pertinent to note that this is based on incomplete and estimative data only from some countries. In many countries, there is no system in place to generate and collate such data. The problem is compounded by the fact that HS Codes are not adequate to classify the data to statistical rigour expected.

Marketing/Trade of MAP

23 HS Code groups cover more than 350 botanicals. There is random clubbing of medicinal plants leading to overlaps and voids where some plants/plant products are covered in more than one group whereas some plants figure in a different group altogether as these are used for different purposes. As an example, spices and essential oils are used in food and perfumery more than as medicinal substances.

The 23 HS Codes which cover medicinal plants (Anonymous, 2011b) are listed in Table 1. Codes like 0902 tea might appear to be incongruous but may include herbal teas based on medicinal plants. Vanila beans, lop cones, coconut, fixed vegetable oils are some more examples. It is obvious that data collated on the basis of these codes can at best be an estimate. Total world

Table 1. HS Codes covering medicinal plants (Anonymous, 2011b)

S. No.	HS Code	Commodity
1	0902	Tea
2	0903	Mate
3	0904	Pepper, genus piper, genus capsicum or pimento
4	0905	Vanilla beans
5	0906	Cinnamon and cinnamon-tree flowers
6	0907	Cloves (whole fruit, cloves and stems)
7	0908	Nutmeg, mace and cardamoms
8	0909	Seeds, anise, badian, fennel, coriander, cumin, etc.
9	0910	Ginger, saffron, turmeric, thyme, bay leaves, etc.
10	1204	Flaxseed (linseed), whether or not broken
11	1210	Hop cones, fresh or dried, lupulin
12	1211	Plants etc. for pharmacy, perfume, insecticides, etc.
13	1212	Locust beans, seaweed, s beet and cane: fruit pits, etc.
14	1301	Lac, natural gums, resins, gum-resins and balsams
15	1302	Veg saps and extracts: pectates etc: agar-agar, etc.
16	1404	Vegetable products nesoi
17	1513	Coconut, palm kernel or babassu oil etc, not ch mod
18	1515	Fixed veg fats and oils nesoi etc, not chem modified
19	1804	Cocoa butter, fat and oil
20	2101	Extracts etc. of coffee, tea or mate, roast chicory
21	3201	Tanning ext. of veg origin, tannins and its salts, etc.
22	3301	Essential oils, resinoids, terpenic by-products, etc.
23	4001	Natural rubber, balata, gutta-percha, guayule, chicle and similar natural gums, in primary forms or in plates, sheets or strip

Table 2. Top 15 countries (value-wise) contributing to the world trade in botanicals (Anonymous, 2011c)

S. No.	Country of export	Value (US$ million)	Per cent to world	World ranking by volume
1	People's Republic of China	3753.82	11.48	2
2	Republic of India	2861.04	8.75	3
3	Kingdom of the Netherlands	2301.04	7.04	7
4	United States of America	1927.90	5.90	9
5	Republic of Indonesia	1785.86	5.46	4
6	Federal Republic of Germany	1745.38	5.34	13

Contd...

Table 2 (contd...)

S. No.	Country of export	Value (US$ million)	Per cent to world	World ranking by volume
7	Democratic Socialist Republic of Sri Lanka	1607.10	4.91	10
8	Republic of the Philippines	1431.60	4.38	1
9	Republic of Kenya	1241.67	3.80	8
10	French Republic	1213.82	3.71	14
11	Malaysia	919.15	2.81	6
12	UK and Northern Ireland	847.43	2.59	15
13	Kingdom of Spain	730.25	2.23	11
14	Canada	701.83	2.15	5
15	Federative Republic of Brazil	655.55	2.00	12
	Total - 15 Countries	**23723.43**	**72.54**	
	Other Countries	8979.47	27.46	
	Total – World	**32702.90**	**100.00**	

trade in botanicals is US$ 32.702 billion of which trade from Asia is US$ 14.505 billion, which accounts for 44.35 per cent (Anonymous, 2011c). The top 15 countries (value-wise) contributing to the world trade in botanicals are listed in Table 2.

It is well known that China and India are leaders in trade of botanicals. The important item of Netherlands is tea leaf and that of USA is *Panax* spp. It may be noted that quite often a plant is processed into extract or essential oil, etc. and then re-exported thus being mentioned under trade from both countries.

Table 3. Top 15 countries (volume-wise) contributing to the world trade in botanicals (Anonymous, 2011c)

S. No.	Country of export	Volume (tons)	Per cent to world	World ranking by value
1	Republic of the Philippines	1395896.57	11.18	8
2	People's Republic of China	1244347.03	9.97	1
3	Republic of India	1161141.95	9.30	2
4	Republic of Indonesia	1108870.79	8.88	5
5	Canada	802797.32	6.43	14
6	Malaysia	631329.87	5.06	11
7	Kingdom of the Netherlands	571943.44	4.58	3
8	Republic of Kenya	433789.98	3.47	9
9	United States of America	413089.72	3.31	4

Contd...

Table 3 (contd...)

S. No.	Country of export	Volume (tons)	Per cent to world	World ranking by value
10	Democratic Socialist Republic of Sri Lanka	377925.30	3.03	7
11	Kingdom of Spain	328552.61	2.63	13
12	Federative Republic of Brazil	256763.24	2.06	15
13	Federal Republic of Germany	235768.93	1.89	6
14	French Republic	218469.06	1.75	10
15	UK and Northern Ireland	132713.13	1.06	12
	Total - 15 Countries	**9313398.93**	**74.59**	
	Others Countries	3173048.47	25.41	
	Total – World	**12486447.40**	**100.00**	

Botanicals from Asia: 23 countries (Table 4) figure in the ITC MNS report of 2011 with a share of US $ 14.505 billion (44.35% of world trade) and a volume of 6.634 million tons (53.13% of total world volume).

Table 4. 23 Countries figuring in ITC MNS report of 2011 (Anonymous, 2011c)

S. No.	Countries	Value (US$ million)	Per cent to world	World ranking by value	Volume (tons)	Per cent to world	World ranking by volume
1	People's Republic of China	3,753.82	11.48	1	1244347.034	9.97	2
2	Republic of India	2,861.04	8.75	2	1161141.948	9.30	3
3	Republic of Indonesia	1,785.86	5.46	5	1108870.787	8.88	4
4	Democratic Socialist Republic of Sri Lanka	1,607.10	4.91	7	377925.301	3.03	10
5	Republic of the Philippines	1,431.60	4.38	8	1395896.572	11.18	1
6	Malaysia	919.15	2.81	11	631329.866	5.06	6
7	Republic of Singapore	456.28	1.40	17	71408.901	0.57	30
8	Islamic Republic of Iran	434.55	1.33	19	76215.367	0.61	28
9	Republic of Korea	264.87	0.81	26	29951.391	0.24	46
10	Republic of Turkey	183.88	0.56	33	62408.204	0.50	34
11	United Arab Emirates	167.04	0.51	35	65506.275	0.52	33
12	Japan	162.05	0.50	36	8612.255	0.07	73
13	Russian Federation	122.43	0.37	41	209486.817	1.68	17
14	Islamic Republic of Pakistan	92.56	0.28	46	53412.898	0.43	36

Contd...

Table 4 (contd...)

S. No.	Countries	Value (US$ million)	Per cent to world	World ranking by value	Volume (tons)	Per cent to world	World ranking by volume
15	Federal Democratic Republic of Nepal	70.05	0.21	52	70405.203	0.56	32
16	State of Israel	57.23	0.17	53	3942.866	0.03	85
17	Islamic Republic of Afghanistan	56.79	0.17	54	13811.864	0.11	61
18	Kingdom of Saudi Arabia	43.32	0.13	61	14625.833	0.12	60
19	Republic of Kazakhstan	16.99	0.05	75	27677.401	0.22	48
20	Sultanate of Oman	7.05	0.02	89	2231.476	0.02	96
21	Hashemite Kingdom of Jordan	6.01	0.02	90	3770.451	0.03	88
22	Kingdom of Bhutan	5.38	0.02	91	1593.704	0.01	100
23	Kingdom of Cambodia	0.13	0.00	128	96.158	0.00	121
	Total - 23 Countries	**14505.18**	**44.35**		**6634668.572**	**53.13**	
	Others Countries	10615.70	32.46		5326514.651	42.66	
	Total - World	**32702.90**	**100.00**		**12486447.404**	**100.00**	

The country-wise trade of major countries under HS Codes related to medicinal plants are given in Table 5, 6, 7 and 8.

Table 5. Trade of China under HS Codes related to medicinal plants (Anonymous, 2011d)

S. No.	HS Code	Medicinal plants	Value (US$ million)	Volume (tons)
1	13021990	Vegetable saps and extracts used in pesticides NESOI	345.72	12150.71
2	12119039	"Other" medicinal (pharmacy) plants NESOI	299.48	140943.86
3	12129993	Pumpkin seed	256.13	74744.92
4	13023912	Algin/Sea tangle	134.69	32969.80
5	33012960	Eucalyptus leaf and branchlet essential oil	90.27	8912.42
6	13023911	Carrageenan	56.67	6751.00
7	12122031	Wakame seaweed, dried	52.11	9299.25
8	12112099	Asian ginseng root, dried	51.35	2570.03
9	13023100	Agar agar	43.02	3979.67
10	12119031	Lycium fruit (goji berries)	40.72	6190.72

Contd...

S. No.	HS Code	Medicinal plants	Value (US$ million)	Volume (tons)
11	12119016	Cordyceps fungus	39.23	2.25
12	12122041	Laver seaweed, dried	37.01	3398.63
13	13023990	"Other" mucilages and thickeners from vegetable products NESOI	34.71	3531.24
		Other medicinal plants	481.26	133278.97
		Total	**1962.37**	**438723.46***
		Other botanicals	1689.42	773714.27**
		Total trade	**3651.79**	**1212437.73**

*53.74% to total trade; **46.26% to total trade;
2011 World trade rank by value: 1; 2011 World trade rank by volume: 2
Botanical commodity count: 107; Medicinal plant commodity count: 81

It can be observed that sea weeds are covered under several codes such as 13023912, 12122031 and 12122041.

Table 6. Trade of India under HS Codes related to medicinal plants (Anonymous, 2011e)

S. No.	HS Code	Medicinal plants	Value (US$ million)	Volume (tons)
1	13023230, 13023220	Guar seed gum, treated and pulverized	604.14	364682.22
2	12119032	Psyllium husk	93.18	38632.70
3	33019029	Spice oleoresins NESOI	60.84	2946.31
4	13021919	"Other" herbal extracts	57.16	1250.30
5	33012590	"Other" essential oils of mint other than peppermint, spearmint, water mint, horsemint, and bergamot mint oil	56.14	2919.97
6	33012400	Peppermint leaf essential oil	40.36	1883.35
7	33019022	Capsicum fruit extracted oleoresin	37.79	1764.75
8	33019013	Black pepper fruit extracted oleoresin	29.12	1361.03
9	33019014	Turmeric rhizome extracted oleoresin	28.77	447.08
10		Other medicinal plants	327.71	120376.62
		Total	**1335.21**	**536264.33***
11		Other botanicals	1744.83	856238.83**
		Total trade	**3080.04**	**1392503.16**

*43.35% to total trade; **56.65% to total trade
2011 World trade rank by value: 2; 2011 World trade rank by volume: 3
Botanical commodity count: 304; Medicinal plant commodity count: 174

Guar gum, Psyllium husk and essential oils are amongst the major botanicals traded from India.

Table 7. Trade of Indonesia under HS Codes related to medicinal plants (Anonymous, 2009)

S. No.	HS Code	Medicinal plants	Value (US $ million)	Volume (tons)
1	3301	Essential oils	147.13	4354.81
2	121220	Seaweeds and other algae	110.15	99948.58
3	130231	Agar-agar	14.21	2467.36
4	130190	Natural gums, resins, oleoresins (balsams)	12.23	15317.03
5	1211	Other medicinal plants	8.68	7640.44
6	140490	Other vegetable products	0.49	241.64
7	130219	Other herbal extracts	0.39	38.59
8	130211	Opium exudate	0.21	9.40
9	130120	Gum Arabic	0.06	20.03
10		Other medicinal plants	0.00	0.00
		Total	**293.56**	**130037.85***
11		Other botanicals	769.56	285590.06**
		Total trade	**1063.11**	**415627.91**

*27.61% to total trade; **72.39% to total trade
2011 World trade rank by value: 5; 2011 World trade rank by volume: 4
Botanical commodity count: 34; Medicinal plant commodity count: 9

It can be observed that essential oils and sea weeds are lead botanicals figuring in Indonesia.

Table 8. Trade of Malaysia under HS Codes related to Medicinal Plants (Anonymous, 2009)

S. No.	HS Code	Medicinal plants	Value (US $ million)	Volume (tons)
1	140490	Other vegetable products	4.89	100350.57
2	1211	Other medicinal plants	3.87	487.89
3	121220	Seaweeds and other algae	1.13	382.67
4	3301	Essential oils	0.87	208.26
5	130190	Natural gums, resins, oleoresins (balsams)	0.77	559.67
6	130219	Other herbal extracts	0.58	187.81
7	130231	Agar-agar	0.26	154.07
8	130120	Gum Arabic	0.03	0.90
9	130213	Hops extract	0.01	1.50
10		Other medicinal plants	0.00	0.00
		Total	**12.41**	**102333.34***
11		Other botanicals	724.48	153287.50**
		Total trade	**736.89**	**255620.85**

*1.68% to total trade; **98.32% to total trade
2011 World trade rank by value: 11; 2011 World trade rank by volume: 6
Botanical commodity count: 36; Medicinal plant commodity count: 9

Following are some pointers emerging from the data related to Asia:

- Though Sri Lanka is at world value rank No. 7 and the Philippines at rank No. 8, there is no detailed data under various HS codes for further classification.
- Tea, spices, coconut have been conventional cash crops from these regions.
- Cinnamon is also a big traded spice-cum-medicinal plant from Vietnam and Sri Lanka.
- Though Taiwan and South Korea are also very active on the Traditional Medicinal segment and have a firm footprint the world over, but there is no data available.
- MNS Reports cite many countries having not filed their trade data and the data filed by some of the countries is not very accurate.
- Though it is known that traditional trade routes to India are from North Africa, Iran, Afghanistan and Indonesia – somehow this data correlation has not been possible.
- High altitude medicinal plants from the Himalayas (Nepal, India, China) and plants from arid regions of Afghanistan play a major role in traditional medicine for India and TCM, but these are not reflected in such data.
- Regions of Sindh, Baluchistan and border of Iran and Pakistan have been known to supply essential gum resins from the dry and arid regions.
- Countries of Southeast Asia have a very rich diversity and dependence on traditional medicinal systems – data may not be compiled but consumption is surely of significance within the country itself.

It is obvious that conclusions that can be drawn from the data should form the basis of policy and strategy for sustained supply of medicinal plants. Some of the important rare, endangered and threatened (RET) species in trade from India and China are listed in Table 9.

Table 9. Important rare, endangered and threatened (RET) species in trade from India and China (Anonymous, 2011d, 2011e)

Commodity	Botanical name	RET status	Volume (tons)		Habit	Parts used
			India	China		
Agarwood (including chips and dust)	*Aquilaria* spp.	CITES	7.59	-	Tree	Bk (St), Wd (Htwd)
Agarwood essential oil	*Aquilaria* spp.	CITES	1.59	-	Tree	Bk (St), Wd (Htwd)
Tendu leaf (*bidi* wrapper)	*Diospyros melonoxylon*	CITES	2118.66	-	Tree	Lf
Ginseng root	*Panax* spp.	CITES	2.37	256.21	Herb	Rt
Ginseng extract	*Panax* spp.	CITES	0.05	-	Herb	Rt
Rauwolfia root	*Rauvolfia serpentina*	CITES	0.05	-	Shrub	Rt
Costus root	*Saussurea costus*	CITES	0.50	-	Herb	Rt, St
Apricot, nectarine, peach, and plum kernels	*Prunus* spp.	CITES		169.91	Tree	Fr (Sd)

Bk: Bark; Fr: Fruit; Htwd: Heart Wood; Lf: Leaf; Rt: Root; Sd: Seed; St: Stem; Wd: Wood

Fact – We Need to Understand

Frankly, not all that much has changed when it comes to a deeper understanding of trade in medicinal plants. This sector has not been overhauled in a manner that we have seen in food related agro-produce being formatted and the clarity we see in 'user' and 'grower' profiles of countries. Technology and science have been employed to maximize productivity, food security being a national priority attention is explainable. Food sector and agro-produce for the world's largest business segment – Agriculture. A similar concerted and strong effort is needed in the medicinal plant sector to ensure sustainable supply for generations to come. It would be simple to format and place this database, as 'agriculture' related data collection dragnet is already in place. It is a matter of priority and attention denied so far.

Defining a Medicinal Plant

An ideal medicinal plant can be described as *"Sustainably sourced from organically certified forests and farms, documentarily supporting traceability and legal procurement, in full compliance of a fair trade guideline and to complete satisfaction of desired quality monographs".*

It may be pertinent to note here that, with effect from July 2013, EU regulations require good agricultural practice, good laboratory practice and good manufacturing practice certification for all botanicals imported by member countries intended for 'medicinal use' (EU Guidelines, 2008). This indicated that all aspects of medicinal plants have to be addressed to achieve the object of sustainable utilization of quality medicinal plants.

For traditional trade channel, the critical and neglected factors that need to be looked into are: i) produce sourced either from forests primarily through tribal communities and or from farms through farmers subsequently moving to weekly markets; ii) produce from both collected by collectors at district level; iii) produce transported to urban market place via traditional/rural/urban transport system; and iv) eventually the produce is transported to pharma companies, perfumeries, herbal extract industries, etc. for value addition purpose.

Basically, this is a great challenge to maintain the balance between three factors, viz., 'Forest – Farm – Pharma' so that sustainable supply and utilization of quality medicinal plants is assured.

Future of Medicine: Evolution and Progress of Modern Medicine

Modern medicine has evolved through the developmental stages mentioned below (Fig. 1) through the arduous journey of so many decades. Even now, it is groping for perfection which is elusive. There are about 200 examples of drugs being recalled from the market after several years of exhaustive safety and clinical evaluation (http://en.wikipedia.org/wiki2011-12). There are many reports of toxicity of extracts, fractions and purified phytoconstituents of medicinal plants prepared using solvents alien to traditional systems of medicine. The very plants have been used safely (in whole form) in the traditional systems of medicine for centuries. It is necessary to look at the traditional wisdom with an open unbiased mind and fpr this a paradigm shift is required.

On the contrary, Ayurveda has been evolved through a strong foundation of holistic approach and utilization of natural resources for the welfare of human beings (Fig. 2). Natural substances

are more in harmony with human body compared to their purified fractions and components. Ayurveda, not only looks at a disease and its cure or mitigation but tries to look at the basic cause and its elimination. It includes mind and soul as well in its endeavour to bring the patient back to complete health. It is essential that this wholistic approach is adopted in modern medicine. It may be noted that as a result of this change in approach, Modern science has now come closer to Wholistic approach. Concept of personalised medicine is now gaining acceptance world over.

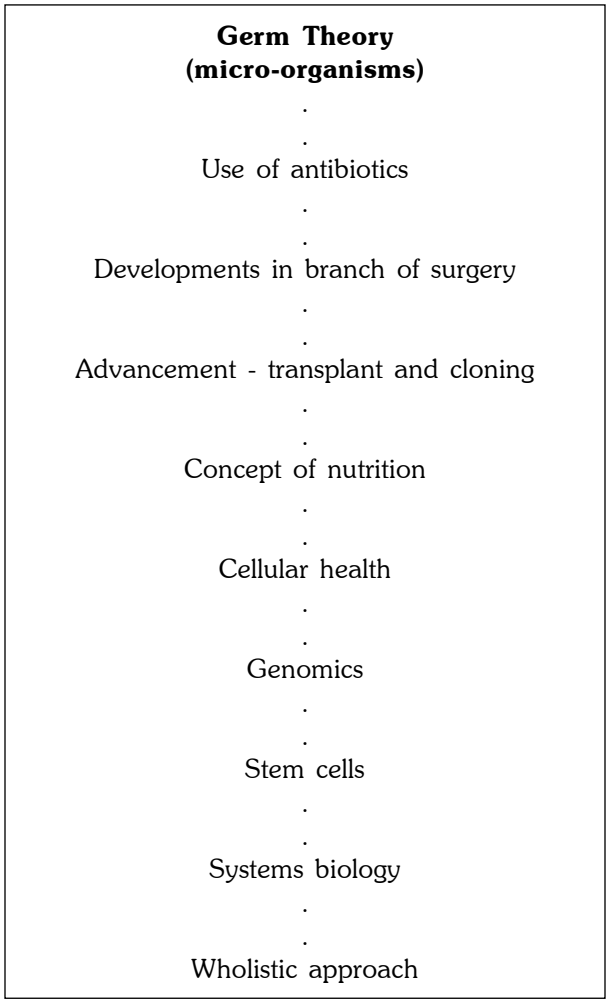

Fig. 1. *Future of medicine - evolution and progress of modern medicine*

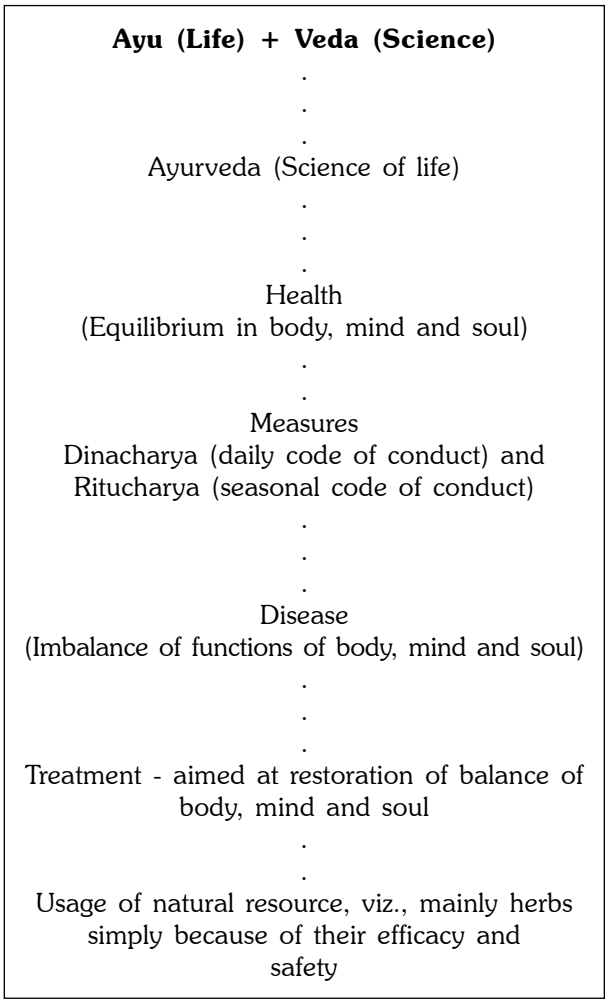

Fig. 2. *Future of medicine - traditional medicine - Ayurveda*

Value Addition

There is a need to consider various stages of a value addition process. The produce that travels from farm to consumer attracts cost factors at various stages such as labour, premises, equipments, handling, analytical testing, packing, shipping, etc. One important factor is that a substantial portion of the crude plant resource gets deteriorated by the time it reaches the user. This is a colossal loss. Moreover the volume transported is much less if processing like sorting, cleaning, drying powdering and extraction are undertaken.

Traceability-aided Lot Marketing

It is essential that medicinal that medicinal plants are commoditized facilitating lot marketing. Traceability is an important requirement of a quality medicinal plant. This aspect of traceability has to be built into the labeling system of medicinal plants. This will also facilitate transportation. The information which should be provided on the label include botanical name, grade, source, medicinal part, lot no., quantity, collected by, method of drying, details of site of collection and period of harvesting/collection, age of plant at the time of harvest/collection. There should also be provision of bar coding to facilitate quick identification.

Conservation

There is an urgent need to understand clearly the meaning of conservation described by CITES, WWF, UNEP and IUCN. It is defined as "*the management of human use of the biodiversity so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations*". This definition suggests and stresses on regeneration. Sometimes, it is inadequately understood to be the basis of bans and curtailment.

There is need to understand the underlying intention and act vigorously to promote and strengthen regeneration. The beauty of medicinal plant resource is that it can be regenerated. History would show that hardly, if any, medicinal plants or botanicals have been delisted from CITES. It indicates a very poor attention and record of regeneration. In the coming years as traditional medicine attains official sanction on proven health benefits, the stress on basic plant resources will hasten the chances of unsustainable harvests taking an adverse toll. Whilst the world has sufficient non-governmental organizations that thrive on identifying species to ban and curtail, there seems to be none that quantitatively encourages and boasts regeneration. The first step towards this backward integration is essential and attainable.

APAARI has commendably addressed 'food security' over the past decades. The FAO and APAARI have taken medicinal plants to be an overall focus area in agriculture. There is an urgent need to focus on importance of traditional therapeutics. It must adopt science and technology in the medicinal plants sector – conservation, cultivation and post-harvest processing of medicinal plants. It should usher in 'era of plenty' to ensure sustainable utilization for generations to come.

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Country Status Reports

Country Status Report on Medicinal and Aromatic Plants in Bangladesh

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Introduction

Bangladesh is situated between latitude 20°34" and 26°38" North and longitude 88°01" and 92°41" East and has a tropical monsoon climate characterized by wide seasonal variations in rainfall, temperature and humidity. It has vast natural resources including medicinal and aromatic plants (MAP). Since decades, MAP species are being used for treating various ailments in human being and domestic animals. Spices Research Center (SRC) of Bangladesh Agricultural Research Institute (BARI) has undertaken research program for developing aromatic crop varieties and Forest Department (FD) initiated tree plantation emphasizing aromatic plants in certain areas. Medicinal plants are not only used in preparation of Ayurvedic and Unani medicines but around 125 species are being used in Allopathic medicines. Raw medicinal and aromatic plants are also used in herbal cosmetics, toiletries and as nutritional foods.

In Bangladesh, 5,000 species of angiosperm are reported to occur (IUCN, 2003). The number of medicinal plants included in the 'Materia Medica' of traditional medicine in this sub-continent at present stands at about 2,000. More than 500 of such medicinal plants have so far been enlisted as growing in Bangladesh (Ghani, 1998). Dhaka, Rajshahi, Sylhet and Chittagong divisions are rich in medicinal plants (IUCN, 2003).

MAP played a significant role in providing primary healthcare service to 80 per cent of the population in Bangladesh. They rely on wild collection from natural forests. But, due to advancement in synthetic drugs and paucity of MAP in nature, the practice of using herbal drugs dropped significantly. The herbal medicines are considered less toxic with no side effects, non-narcotic and easily available and sometimes the only source of healthcare to the poor. Unfortunately, these valuable resources have been depleting rapidly because of unsustainable exploitation, deforestation and changes in land-use patterns. As a result, many species of medicinal and aromatic plants have become extinct and many more are threatened and endangered. According to IUCN Red Data Book, 106 plant species in Bangladesh are endangered. Among them, eight species have medicinal value. These are *Andrographis peniculata, Rauvolfia serpentina*, *Terminalia citrina*, *Cycas pectinata*, *Dioscorea prazeri*, *Cymbidium aloifollium*, *Amomum costatum* and *Zingiber roseum*. As a consequence, the country will face serious ecological imbalance and biodiversity loss. The emerging global climate change might accelerate the consequences several folds.

Considering the present situation, there is a need to stop or halt the decline of this valuable resource and urgent action is solicited at local, national, regional and international levels to revive the threatened and endangered species at a sustainable level.

Area, Production and Productivity

The studies revealed that no comprehensive survey has yet been undertaken to assess the total cultivation area coverage of MAP in Bangladesh. But, sporadically small farmers are profitably cultivating these species in small strips of lands in their homesteads in the rural areas.

Helvetas, Swiss Inter Cooperation reported that 60,000 producers involved in cultivating five commercially important MAP species like *Withania somnifera* (aswaganda), *Ocimum tenuiflorum* (tulsi), *Asparagus resimosus* (satamuli), *Adhatoda vasica* (basak), and *Andrographis paniculata* (kalmegh) in 62 unions of 30 sub-districts and 11 districts of 3 divisions (Fig. 1). Out of the total producers, 98 per cent are poor and pro-poor and 80 per cent of them are female. The area under cultivation is 450 km roadside, 33.40 ha unfertile cultivable land, 60.12 ha homestead and other fallow lands. There are 270 seed/seedling suppliers, 320 local service providers, 62 collection centers and 39 collectors that supply the raw material to ACME and Square Pharmaceuticals (SEDF/IC, 2003).

Recently, some pharmaceutical companies are emerging as producers of herbal medicines importing huge amounts of raw MAP ingredients. In line with the demand of pharmaceuticals, cultivation is becoming both profitable and environment friendly.

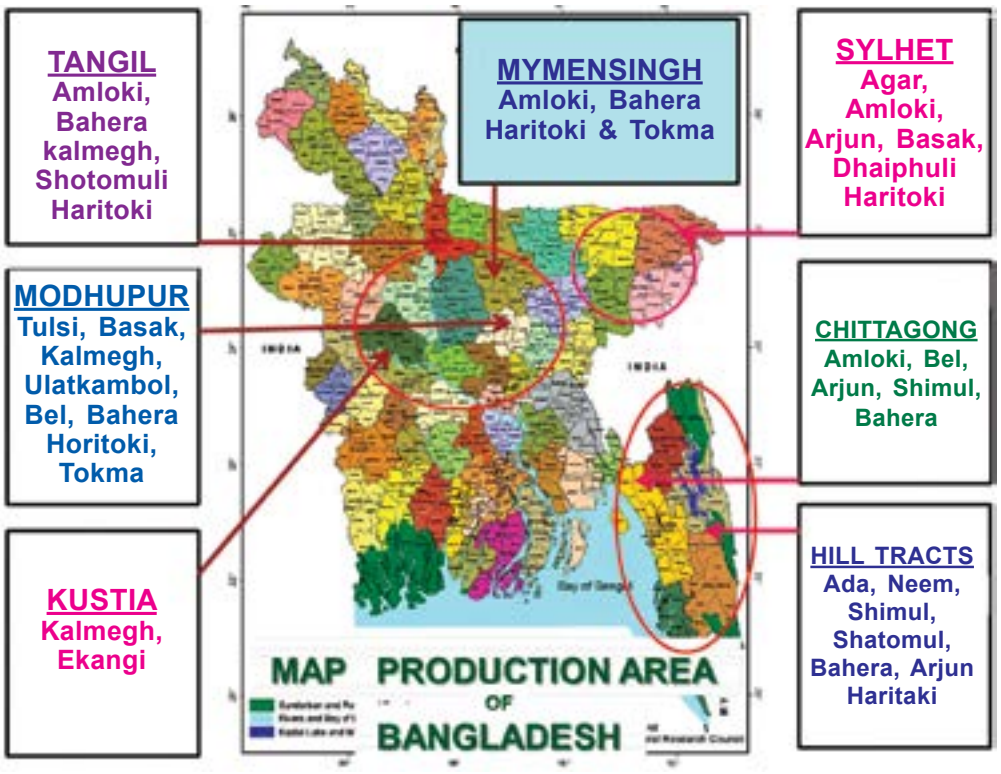

Fig. 1. *Medicinal and aromatic plant production districts in Bangladesh*

Hill Tracts of Bangladesh covers an area of 13,295 ha which is one-tenth area of total land with thirteen indigenous communities. The 90 per cent of hill tract area is hilly, 4 per cent covers villages, rivers and marshes, and remaining 6 per cent is suitable for agriculture. Tribal groups (13) are mostly forest dwellers and practice jhumming i.e. shifting cultivation (Banik *et al.*, 1998) and have good potential for commercial production of MAP.

Under Bangladesh Agriculture Research Council (BARC) fund, Bangladesh Forest Research Institute (BFRI) implemented a coordinated project for initiating cultivation of market demanding five different medicinal plant species targeting poverty alleviation and environment enrichment through agroforestry system in Chittagong Hill Tract. Conservation of all medicinal plants require basic studies on traditional knowledge on the use of plants in healthcare and studies to identify the medicinal plants, outline their distribution and assess their abundance. Therefore, conservation of such a valuable resource in the country is vitally important.

Major Uses

The major form of healthcare in the rural parts of developing countries is traditional medicine prepared by racial old fellows and *Kobiraj/Boidayas* (local herbal practitioners), which is mostly plant-based. For example, *Vitex negundo* has diverse medicinal uses in the folk system of Bangladesh. Actually, the ethnic and rural people in Bangladesh solely depend on MAP for their primary healthcare and they have a well developed system of herbal medicine to cure almost all ailments.

Most of the MAP species in Bangladesh are extensively used in the preparation of Unani, Ayurvedic and Homoeopathic medicines. MAP also serve as important raw materials for many modern medicinal preparations i.e. allopathic medicines. The aromatic plants in Bangladesh cover 60 families and various species are used in cosmetics and beautification purposes.

Some of the aromatic plants are directly used as food, some as flavouring foods and other as spices which have special function to prolong table life, increase palatability of the food-stuff (Table 1). Most of the aromatic plant species have special chemicals which act as preservatives. Some of the fragrant or aromatic plants have also woody stems like sandal wood which emits fragrance and refresh room air. Agar is also a valuable aromatic plant. In Bangladesh, current production of agar is valued at US $ 1.7 million with a projected annual growth rate of 5 per cent (Dixie *et al.*, 2003).

Table 1. Diversified uses of medicinal and aromatic plants in Bangladesh.

S. No.	Name of species	Parts used	Uses
Healthcare/medicinal use			
1.	*Andrographis paniculata* Nees.	Whole plant	Skin, liver disease
2.	*Adhatoda zylanica*	Leaves	Caugh, cold
3.	*Cassia alata* L.	Leaves	Scabies
4.	*Withania somnifera* Dunal.	Roots	Sexual stimulant

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Table 1 (contd...)

S. No.	Name of species	Parts used	Uses
5.	*Asperagus resemosus*	Roots	Dysentery
6.	*Rauvolfia serpentina* Linn.	Roots	High blood pressure
7.	*Terminalia arjuna* W. and A.	Bark	Heart disease
8.	*Acorus calamus* L.	Rhizome	Cough, cold
9.	*Abroma augusta*	Root, bark and stem	Anti-abortion
10.	*Coccinia grandis* Linn.	Leaves	Diabetes
Cosmetics			
11.	*Lawsonia inermis* L.	Leaves	Hand and hair dying
12.	*Sapindus mukorossi* Gaerth.	Fruits	Shampoo
13.	*Zingiber zerumber* Sm.	Rhizome	Medicinal and cosmetic
Flavouring			
14.	*Piper betel* L.	Leaves	Elachi flavor
15.	*Pandanus* spp.	Leaves	Rice flavoring
16.	*Cymbopogon citratus*	Leaves	Flavoring curry, soup, etc.
17.	*Citrus* spp.	Leaves and fruits	Flavoring curry, soup, etc.
18.	*Foeniculum vulgare* Mill.	Fruit and seed	Flavoring dishes
Toiletries			
19.	*Vetiveria zizaniodes* (L) Nash	Roots	Air freshner

Significant Achievements

Germplasm collection, characterization, conservation and documentation

Plant Genetic Resources Center (PGR) was established at BARI in 1983. The Center operates a network of its five regional stations representing different phytogeographical regions with distinct ecological conditions in the country. These are located at Ishurdi, Jamalpur, Burirhat, Jessore and Khagrachari. It also has three clonal gene banks at Jaintapur, Sylhet; Rahmatpur, Barishal and Binodpur, Rajshahi. The Center has office-cum-laboratory, experimental field and other physical infrastructures at headquarter and different regional stations. It has long-term and medium-term conservation units, Seed Processing Laboratory, *In vitro* and Cryopreservation Laboratory, Molecular Biology Laboratory, Seed Health and Quarantine Laboratory, Documentation Laboratory, Greenhouse and Isolation Chamber, Field Laboratory, etc. The center not only provides genetic resources to on-going crop improvement program to sustain continued advances in agricultural productivity and stabilize production but also conserves them safely to meet the needs of future generations.

The Government is deeply concerned about the rapid depletion of forest resources that includes medicinal and aromatic plants. In this situation, information on existing MAP, their identification,

ecological niches and their conservation measures are to be undertaken through scientific study for documentation and deriving benefits for the humankind.

Estimated number of species of medicinal plants in Bangladesh is about 5,000 (Rahman, 2007). Khan (1998) cited that National Herbarium prepared a revised list of medicinal and aromatic plants that exceeds 500 species. Bangladesh Forest Research Institute, Minor Forest Products Division tried to make an inventory list of 220 MAP and documented their habitat, distribution, flowering time and healing ailments (Rashid *et al.*, 1990). Bangladesh Council of Scientific and Industrial Research (BCSIR) identified 747 medicinal plants (Yusuf *et al.*, 1994). IUCN made a comprehensive survey on selected medicinal plants of Chittagong Hill tracts and listed 31 species that are being regularly used by tribal people (Motaleb, 2011). Asiatic Society of Bangladesh enlisted 1,611 MAP (Ghani, 1998). Khisa (1996) recorded more than 500 plant species used by traditional practitioners for medical purpose out of which 135 species are taxonomically identified.

Prior to initiation of small scale cultivation of MAP in Bangladesh, the most of the wild medicinal plants were exploited resulting significant loss from the nature. It is the right time to undertake germplasm collection, conservation and documentation of plant genetic resources of MAP and prepare the inventory of collection. The world conservation strategy (WHO/ IUCN/WWF, 1993) defines conservation as "The management for human use of the biodiversity, so that it may yield the greatest sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of future generations". The germplasm conserved in the field gene bank is given in Table 2.

BFRI collected germplasm of 85 species (annual and perennial) of rare medicinal and aromatic plant species and developed their propagation, nursery and plantation, and management techniques and also documented through scientific articles and published bulletin, folders, leaflets and poster as extension material for use at the grass root level. Different universities are also playing active role for the perpetuation of medicinal plants. The Bangladesh National Herbarium initiated germplasm collection of MAP. Different pharmaceuticals are also playing indirect role for germplasm collection through contact farming and apprising the farmers about their interest.

In Bangladesh, presently there are twenty two areas for *in situ* conservation under the management of Forest Department. The protected areas are spread almost all over the country covering an area of 243,677 ha. According to IUCN categories of protected areas, there are nine national parks, seven wildlife sanctuary and one game reserve. The location, area and year of establishment of 22 notified protected areas of Bangladesh are provided in Table 3. In some of these protected areas, survey of flora have been completed which revealed a large number of medicinal and aromatic plants, but detailed work to conserve the medicinal plants is yet to be done to achieve sustainable yield of MAP from these protected areas.

Variety development

Very little efforts have so far been made towards development of high yielding varieties of medicinal and aromatic plants in Bangladesh. However, there is no information available on any specific variety developed and released for general cultivation by the farmers.

Table 2. List of medicinal plants conserved in the field gene bank at PGRC, BARI (2012-2013)

Scientific name	English name	Bengali name	Family	Plant part(s) used	No. of accessions
Adhatoda zeylanica Nees	Malabar nut	Basak	Acanthaceae	Leaves	1
Aegle marmelos (L) corr.	Wood apple	Bel	Rutaceae	Fruit	1
Alocatia indica (Roxb)	Giant taro	Mankachu	Araceae	Corm	1
Aloe vera Tour. Ex L.	Aloe	Ghritakanchan	Liliaceae	Leaves, juice	1
Amorphophallus campanulatus (Roxb) Decne	Elephant's foot	Ol kachu	Araceae	Tuber, rootstock, plant	1
Annona reticulate L.	Bullock's heart	Ata	Annonaceae	Leaves, fruit pulp	1
Annona squamosa L.	Custard apple	Sharifa	Annonaceae	Leaves, barks fruits	1
Ardisia solanaceae (Poir) Roxb.	Wild berry	Ban-jam	Myrsinaceae	Roots	1
Artocarpus heterophyllus Lamk.	Jackfruit	Kathal	Urticaceae	fruits leaves and roots	1
Artocarpus lakoocha Roxb.	Monkey jack	Deowa	Urticaceae	Seeds, bark	1
Averrhoa carambola L.	Bilimbi	Bilimbi	Oxalidaceae	fruits	1
Averrhoa carambola L.	Carambola	Kamranga	Oxalidaceae	fruits	1
Azadirachta indica A. juss.	Indian liac	Neem	Meliaceae	Bark, fruits, leaves	1
Carica papaya L.	Papays	Papeya	Caricaceae	Seed oil	1
Carissa congesta Wight.	Karaunda	Karamcha	Apocynaceae	Latex, fruit, seeds	1
Citrus grandis (L) Osbeck.	Pummelo	Jambura	Rutaceae	Leaves, fruit	1
Citrus limon (L) Burm. F.	Lemon	Lebu	Rutaceae	Fruit, juice, leaves	1
Colocasia esculenta (L) Schott	Taro	Mukhi kachu	Araceae	Fruit, juice	32
Curcuma domestica Val.	Turmeric	Halud	Zingiberaceae	Rhizome, flower	1
Cymbopogon citratus (Dc.) Stapf.	Lemon gress	Lebugondhi ghas	Gramincae	Plant	1
Dillenia indica L.	Dillenia	Chalta	Dilleniaceae	Fruit	61
Dioscorea alata L.	Yam	Mete alu	Dioscoreaceae	Tuber	1
Diospyros peregrine (Gaertn) Gurke.	Indian persimon	Deshi Gab	Ebenaceae	Bark	1
Elaeocarpus seratus L.	Oliva	Jalpai	Eleocarpaceae	Leaves, fruits	1

Contd...

Table 2 (contd...)

Scientific name	English name	Bengali name	Family	Plant part(s) used	No. of accessions
Emblica officinalis Geartn.	Aonla	Amlaki	Euphorbiaceae	Fruits	1
Euphoria longan (Lour.)	Longon	Ashphal	Sapindaceae	Fruits, aril	1
Feronia limonia (L) Sw.	Elephant's foot apple	Kathbel	Rutaceae	Fruit, leaves	1
Flacourtia jangomas (Lour) Racus	Flacoutia	Lukluki	Flacourtiaceae	Fruit, leaves, shoots bark	1
Grescentia culete	Galabash tree	Bely bel		-	1
Garcinia cowa Roxb	Cowa	Kau	Gutifera	Fruits	1
Luchi chinensis Sonn.	Lichi	Lichu	Sapindaceae	Fruit, leaves, seed	1
Mangifera indica L.	Mango	Aam	Anacardiaceae	Leaves, seeds, fruit, bark	1
Manikara zapat (l) Royen	Sapota	Sofeda	Sapotaceae	Bark, fruit, seeds	1
Moringa olefera Lamk.	Drumstick	Sajna	Moringaceae	Roots, bark, fruit	1
Musa paradisiaca	Plantain	Kanch kola	Musaceae	Roots, stems, fruit	1
Phoenix sylvestris (L.) Roxb.	Date palm	Khajur	Palmac	Sap, fruit, root	1
Psidium guajava (L) Bat.	Guava	Peyara	Myrtaceae	Leaves, roots, flowers, fruits	1
Phyllanthus distichus Mull-Arg	Star gooseberry	Arbori	Euphorbiaceae	Fruit, root, seeds	1
Polygonum orientale L.	Oriental pepper	Bishkatali	Polygonaceae	Plant	1
Saraca indica L.	Ashoka	Ashok	Caesalpiniaceae	Bark	1
Spondius mangifera Willd	Hog pium	Amrha	Anacardiaceae	Fruits, bark	1
Syzygium jambos (L). alston.	Rose apple	Golapjam	Myrtaceae	Leaves, fruits, bark	1
Syzygium cumini (L) SBlack plum	Black plum	Kalojam	Myrtaceae	Bark, leaves, fruits, Seeds	1
Tamarindus indica L.	Tamarind	Tetul	Leguminosae	Fruit pulp, bark	1
Tarminalia bellirica Roxb.	Myrobalan	Bohera	Combretaceae	Fruit, fruit oil	1
Vitis vinifera	Grape	Angur	Vitaceae	Fruit	1
Zizyphus mauritiana Lamk.	Jujube	Kul	Rhamnaceae	Fruits	1
Zingiber officinale Rosc.	Ada	Ada	Zingiberaceae	Rhizome	18

Table 3. Location, area and establishment year of 22 notified protected areas of Bangladesh

S. No.	Category	Name of the protected area	Location	Area (ha)	Year (Estb.)
1.	National park	Bhawal National Park	Gazipur	5,022	1974
2.	National park	Modhupur National Park	Tangail/Mymensingh	8,436	1962
3.	National park	Ramsagor National Park	Dinajpur	28	2001
4.	National park	Himchari National Park	Cox's Bazar	1,729	1980
5.	National park	Lawachara National Park	Moulavibazar	1,250	1996
6.	National park	Kaptai National Park	Chittagong Hill Tracts	5,464	1999
7.	National park	Nijhum Dweep National Park	Noakhali	16,352	2001
8.	National park	Medha Kassapia National Park	Cox's Bazar	396	2004
9.	National park	Satchari National Park	Hobigonj	243	2005
10.	W L Sanctuary	Rema-Kelenga Wildlife Sanctuary	Hobigonj	1,796	1996
11.	W L Sanctuary	Char Kukri-Mukri Wildlife Sanctuary	Bhola	40	1981
12.	W L Sanctuary	*Sundarban (East) Wildlife Sanctuary*	Bagerhat	31,227	1996
13.	W L Sanctuary	Sundarban (West) Wildlife Sanctuary	Satkhira	71,502	1996
14.	W L Sanctuary	Sundarban (South) Wildlife Sanctuary	Khulna	36,970	1996
15.	W L Sanctuary	Pablakhali Wildlife Sanctuary	Chittagong Hill Tracts	42,087	1983
16.	W L Sanctuary	Chunati Wildlife Sanctuary	Chittagong	7,761	1986
17.	Game Reserve	Teknaf Game Reserve	Cox's Bazar	11,615	1983
18.	O Con. Sites	National Botanical Garden	Dhaka	84	1961
19.	O Con. Sites	Balda Garden	Dhaka	1.37	1909
20.	O Con. Sites	Madhabkunda Eco-Park	Moulavibazar	266	2001
21.	O Con. Sites	Sitakunda Botanical Garden and Eco-Park	Chittagong	808	1998
22.	O Con. Sites	Dulahazra Safari Park	Co'x Bazar	600	1999

Source: Bangladesh Forest Department (http://www.bforest.gov.bd)

Cultivation practices

BFRI initiated standardization of cultural practices of much needed five medicinal plants in hilly area through agro-forestry system addressing good cultural practices and is helping to develop linkage between producers and commercial users (Pharmaceuticals). This venture will create an avenue of extending cultivation of MAP in greater hill districts as cash crop for alleviating poverty of tribal people.

In Bangladesh, 18 priority medicinal plants in the judgment of 50 herbal physicians (*Kobiraj*) of Shyamnagor Upazila of Satkhira district and seven priority medicinal plant species which are

being commercially grown currently in Natore district of Bangladesh. It has been found that six species, viz., amloki (*Embelica officnalis* Gaertn); ashok (*Saraca indica*); aswagandha (*Withania somnifera* Linn) dunai; bael (*Aegle mermelos* Linn) corr, gulancha (*Tinospora cordifolia*) miers, shatomuli (*Asparagus racemosus* willd) are common between the Task Force priority list and the herbal physicians priority list and two species *i.e.* aswagandha (*Withania somnifera* Linn) dunai and shatomuli (*Asparagus racemosus*) are found to be common between those under commercial cultivation in Natore and in Task Force priority list, one species aswagandha (*Withania somnifera* Linn.), dunai is found to be common in all the three cases (Rahman, 2007). Therefore, these six species are recommended for large scale cultivation for medicinal use in Bangladesh. There is a growing demand for natural product based medicines, health products, pharmaceuticals, food supplements, cosmetics, etc. in the national and international markets. For meeting the existing demand, cultivated material is more appropriate for various medicinal uses. Systematic cultivation of medicinal and aromatic plants needs following research and development support:

- Good silviculture practices including selection, identification, propagation methods, seed preservation, nursery techniques, cultivation techniques, harvesting, step-wise quality control of raw material up to processing stage and also post-harvest treatment, storage and safety
- Development of protocols for producing planting materials with desirable agronomic and therapeutic chemical derivatives
- Organic farming of medicinal plants as per pharmaceuticals requirement

The herbal pharmaceutical companies initiated farming of selected MAP through contract farming. This activity is expanding faster. But, there is no organized data based information about the area brought under cultivation of medicinal and aromatic plants in Bangladesh. Most of the data are sporadic in nature. Recently, extensive MAP cultivation started in northern and hilly areas keeping in view the quality production.

Disease and pest management

Use of synthetic chemicals to control pests and diseases and chemical fertilizers to increase productivity of medicinal and aromatic plants is discouraged by Bangladesh Government to avoid adverse residual effect. Farmers are encouraged to use biopesticides and biofertilizers to produce quality raw material as demanded by pharmaceutical industry. To avoid pesticide residual hazards in the first place of occurrence at field level, pharmaceuticals are encouraging contract farming and necessary field visits to control the use of unapproved chemicals. For example, pyrethrin- a natural insecticide derived from the *Pyrethrum* plant is used to control pest like cut-worms of *Artemisia annua*, a plant known to cure malaria (Anon, 2007).

Considering the little information available on organic cultivation practice, biological control of pests and active ingredients of five selected commercially important species, BFRI has undertaken studies to develop sustainable cultivation techniques, ways and means of biological pest control and evaluation of active ingredients of these species in hilly area. In order to address the pest and disease management, the cultivation sites were attacked by pests and pathogens in different stages and seasons. Specimens of attacking pests and pathogens were collected from the site for rearing and identify the nature and extent of damage. After rearing,

it was identified that most of the affected parts of the medicinal plants were attacked by mole cricket, psyllid and red mite which are responsible for the damage at seedlings and growing stages in the field. Rate of infestation and symptoms were recorded.

As a preventive measure, neem (*Azadirachta indica*) oil was applied. At nursery stage, aswagandha (*Withania somnifera*) is more susceptible to fungus and insect attack because of water logging in rainy season. Necessary management techniques developed to overcome infestation of pests and pathogens in the nursery and plantation site are given in Table 4.

Table 4. Pest and disease management techniques in nursery and grow-out stage of selected medicinal plants

Medicinal plant	Pest	Disease	Control measure	Remarks
Adatoda zylanica (basak)	Mole cricket	-	Insect allowed to come out by watering and picked manually	-
Andrographis paniculata (kalmegh)	Mole cricket	-	Insect allowed to come out by watering and picked manually	-
Withania somnifera (aswagandha)	Psyllid, red mite	-	Applying 30% aqueous solution of *neem* oil	60% controlled after 3 alternate spraying
	Aphid, scale insect	-	Applying 30% aqueous solution of *neem* oil	60% controlled after 3 alternate spraying
	-	Root rot	Spraying bourdex mixture every week until recovery	-
	-	Leaf blight	Spraying bourdex mixture every week until recovery	-
Andrographis paniculata	Not identified	Stem rot	10-20% aqueous solution of red chili	Control primary attack

Source: SPGR Report/2012

The use of weed killers and pesticides may result in a risk to the environment, to the growers and the medicinal and aromatic plant itself. Therefore the use of chemicals (if use at all) should be reduced to an absolute minimum, and where chemicals are used, necessary regulations should be in place and rigidly followed.

Production of quality seed and planting material

National seed center, BFRI, Forest Department, University, BARI, BCSIR, Departments of Horticulture, Agriculture and Extension, NGOs and other institutions produce quality seed and planting material in variable quantity and dispatch to the farmers. Efforts are in place to train farmers and nursery growers for quality seed and planting material production techniques. In Bangladesh, significant number of nurseries have been developed to meet the requirement of farmers and pilot planting.

National Seed Board is responsible for certification of domestic and imported seeds to safeguard the farmers. BFRI, Seed Orchard Division supply forest species seeds to Forest Department. Organized efforts are needed to synchronize the activities.

Primary processing, value addition and product development

Basically to address an ailment by general people, medicinal plant parts are used in raw form but *Boidayas* prepared herbal medicines adopting partial processing like grinding, paste and tablet forming and drying. The emergence of herbal pharmaceuticals dictated the harvesters and cultivators for initiating pre-processing like cleaning, sorting, grading, drying and subsequent delivery to the pharmaceutical companies in compliance with their purchase specification. This activity might term as value addition to a small extent. Direct value addition like powdering, paste forming and product development is done by pharmaceutical industry itself and is kept as trade secret.

Marketing, commercialization and trade

Medicinal plants are primarily used in Ayurvedic, Unani and Homoeopathic drugs in Bangladesh where herbal medicines have been used for centuries; the most important markets are the rural consumers. Each year, companies producing herbal medicines are importing huge amounts of raw plant ingredients into Bangladesh. The cultivation is becoming both profitable and environmentally friendly. The Government has encouraged the development of the industry since the Prime Minister launched 'Tree Plantation Fortnight' in 2002 with a call to plant medicinal plants and fruit trees. It is estimated that around 12,000 tons of dried medicinal plants are sold from the rural collection and production areas worth around US $ 4.5 million to the rural economy. The wholesale value is estimated to be US $ 6.0 million and the import of around 5,000 tons worth US $ 8.0 million. In summary, the MAP sector in Bangladesh is worth US $ 14.0 million with local supply comprising of 70 per cent by volume and 40 per cent by value (SEDF/IC, 2003). Dey (2006) using data obtained from Hamdard Laboratories Limited noted that the annual demand of medicinal plants is around 19,250 tons in the country. Out of this, medicine industry uses 10,800 tons, herbal physicians use 6,050 tons and cosmetic industries use 2,400 tons. Therefore, conservation of such a valuable resource in the country is vitally important. Fig. 2 visualizes the existing marketing value chain of MAP materials.

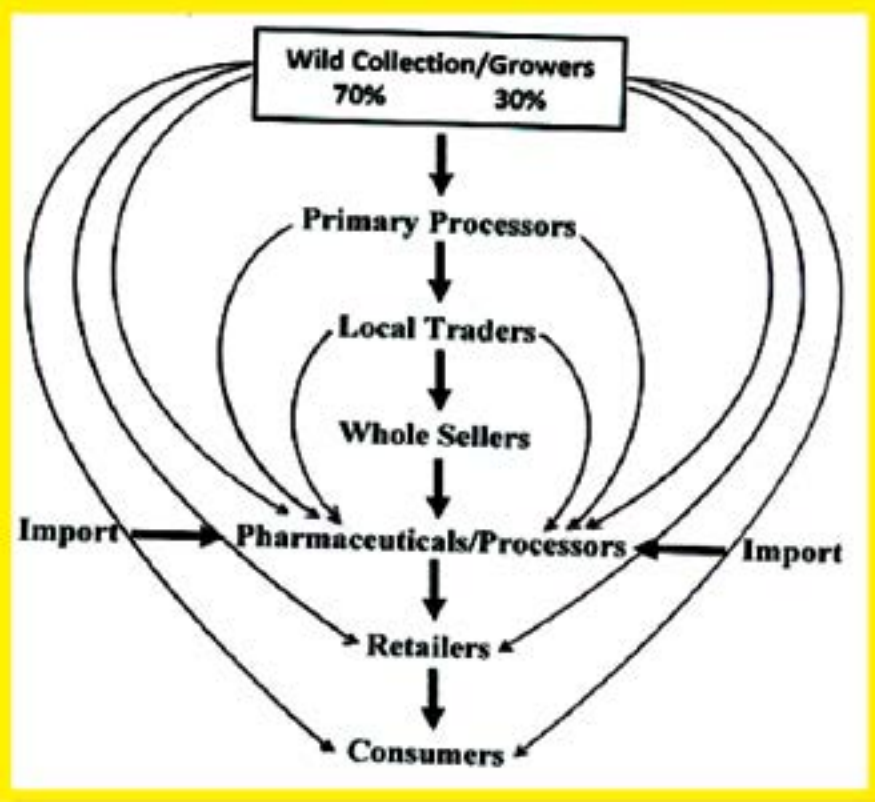

Fig. 2. *MAP materials value chain*

Market potential of medicinal plants

Since ancient times, plants have been used to heal and cure diseases and to improve human health and wellbeing. MAP species play a significant role in meeting the demands of the traditional medicine market, both domestic and overseas markets. Bangladesh herbal medicine domestic market is valued at BDT 330 crore (approximately US $ 60 million) as trade price. Table 5 exhibits discipline-wise medicinal plants value and volume requirement as raw material.

Table 5. Sector-wise MAP raw material usage in terms of value and quantity

Sector	Local supply		Import		Total	
	BDT million	US $ million	BDT million	US $ million	BDT million	US $ million
Unani	127	2.20	127	2.20	254	4.40
Ayurvedic	82	1.40	100	1.75	182	3.15
Herbal doctors	45	0.80	54	0.95	99	1.75
Self treatment	76	1.30	200	3.50	276	4.80
Total	**330**	**5.70**	**481**	**8.40**	**811**	**14.10**
Raw material	12,500 tons		5,000 tons		17,500 tons	

Source: SEDF/IC,2003

Constraints and Opportunities

Traditional medicines

Constraints

- Extinction and/or non-availability of medicinal plants for traditional medicine and less effort to accumulate and standardize traditional knowledge from *Boidayas* (local herbal practiceners)
- *Boidayas* are not interested to disclose ethnic knowledge to others and also are reluctant to use standard tools in preparing traditional medicine
- Traditional medicine practitioners have no institutional education, and absence of awareness building campaign of traditional medicines
- Slow healing of diseases and arbitrary dose determination
- Quality control measures absent in the preparation of traditional medicines and flavour, colour and smell not favouring
- In urban areas, non-availability of traditional medicine, lack of market information and media coverage, and no effort to recognize or certify the traditional medicine practitioners

Opportunities

- Low cost, affordable price, user friendly and no side effects and hence increasing its acceptance

- Institutional education/training to traditional practitioners will definitely expand herbal medicine usage with greater proportions of people can be brought under primary health service
- Popularization of MAP might emerge as homestead pharmacy
- Establishment of modern machineries and quality control in the preparation of traditional medicine will create potential opportunity
- Documentation and standardization of traditional medicine and subsequent certification will emerge as an alternate choice of modern synthetic drug, with establishment of indirectly eco-friendly environment

Modern medicines

Constraints

- Expensive and consequence of side effects on human health
- Pathogens are getting resistance and needed higher dose to cure the disease

Opportunities

- Instant relief and controls the disease quickly
- Strong research feedback and educated practitioners

Approaches for Meeting Emerging Challenges

Medicinal and aromatic plants are not only used for medicinal purpose but also play a significant role for the preparation of toiletries, cosmetics, organic manure, bioinsecticide, feed additives, nutrient supplement, health food, herbal drinks, etc. resulting their declination in nature. For safe existence of humankind, effective measures are needed to arrest extinction of plants. In order to face these challenges; the following aspects need be addressed on priority:

- Documentation of *Kobiraj/Boidayas* traditional knowledge for applied research
- Comprehensive taxonomical and status/abundance oriented survey of medicinal plants is very essential engaging *Kobiraj/Boidayas* and plant taxonomists
- Medicinal plant germplasm conservation and cultivation sites preferably be located in hilly, plain land, marshy and coastal land considering their ecological niches
- Medicinal plant growers are to be trained on good agricultural practice (GAP) for enhancing production, quality raw material and traceable supply to meet pharmaceuticals demand
- Commercial cultivation of medicinal plants through public-private-partnership (PPP)
- Development of network among regional research institutions of medicinal plants for mutual benefits and to face future challenges collectively
- Regulatory policies are to be framed on uncontrolled harvesting of wild medicinal plant from open forests

- Mass media may take lead to popularize herbal medicine in view of its low side effects on human health
- Dreadful diseases like AIDS and cancer have not yet developed any curative treatment through modern medicine but scientists believe its curative agent might be available in medicinal plants that have to be explored.

Future Thrusts

- Development of tissue culture facility for large scale production of seedlings to meet the growing demand
- Traceable quality and quantity of organic raw materials
- Trained/qualified herbal medicine practitioners
- Gene bank and database information on MAP species
- Establishment of property rights and inter-regional network to strengthen cooperation
- Unveil traditional medicine healer knowledge for applied research and dose determination
- Advance precautionary measures to face effect of global weather change on MAP species
- Conservation and pilot plantation of MAP species

Conclusion

Date back from pre-historical era, the plant kingdom is playing a holistic health service to the animal kingdom. The value of medicinal and aromatic plants to human livelihood is essentially infinite. They obviously make fundamental contributions to human health, feed additives, nutrient supplement, health food, herbal drink, toiletries, flavour and fragrance, etc. Large quantities of MAP are traded into urban centers for uplifting the socioeconomic condition of teeming millions of rural and tribal people. Traditional plants and herbs are used for the treatment of various diseases because plant based herbal drugs are safe in different aspects when compared with synthetic drugs. Many species of MAP have become extinct and many more are threatened and endangered. There is also an urgent need to conserve the habitats of the endangered MAP species which are on the verge of extinction in tropical ecosystem. In order to resist the decline of these renewable resources and uphold the user friendly traditional healing heritage, urgent action is needed at local, national, regional and international levels. In Bangladesh, annual turnover of leading Ayurvedic sector is around BDT 1,000 million, Unani around BDT 1,800 million, and Homeopathy around BDT 500 million. It indicates that this sector has huge potential for development as well as export earning that needs to be tapped through research, commercialization and conservation.

Bangladesh Government formed a cell under the Ministry of Environment and Forest for the development of medicinal plants. The cell is functioning well and addressing different areas such as seedling production through tissue culture, leasing land for medicinal plant culture, etc. Above all, organized efforts are needed to harmonize the activities of various institutions to meet the challenge of MAP requirement.

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Country Status Report on Medicinal and Aromatic Plants in Bhutan

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Introduction

Bhutan is a mountainous, largely forested country with a large ecological variability, limited agricultural area and an economy that relies heavily on sustainable utilization and protection of land resources. The total geographical area of Bhutan is 38,395 km^2 with 80.9 per cent forest cover, 70.5 per cent tree cover and 2.93 per cent cultivated agriculture area (LCMP, 2010). The agro-ecological zones (AEZs) of Bhutan have been categorized into six major classes based on altitude range, mean annual rainfall and mean annual temperature (MoA, 2009). The distribution of geographical area based on AEZs is given in Table 1 (Bhutan RNR Statistic, 2012).

Table 1. Agro-ecological zones and geographical area distribution

Agro-ecological zones	Altitude range (m asl)	Annual rainfall (mm)	Mean temperature (°C)	Geographical area (km^2)
Alpine	3,600-7,500	<650	5.5	10,980.97
Cool temperate	2,600-3,600	650-850	9.9	9,176.405
Warm temperate	1,800-2,600	650-850	12.5	7,141.47
Dry subtropical	1,200-1,800	850-1,200	17.2	5,029.745
Humid subtropical	600-1,200	1,200-2,500	19.5	3,916.29
Wet subtropical	100-600	2,500-5,500	23.6	2,150.12

Bhutan's vast topography and unique geographical setting harbours around 7,000 different species of plants of which 600 species have been identified with medicinal properties and over 300 species are in traditional use. Bhutan has been referred to as "*Lho Jong Men Jong*" - the Southern Land of Medicinal Herbs and the Bhutanese people have been practicing an age old medical institution called the *gSo-ba-Rig-pa* since eighth century. The advent of Zhabdrung Nawang Namgyel in the 17th century further laid emphasis to its recognition and spread the knowledge

of traditional medicine whereby *gSo-ba-Rig-pa* was officially incorporated in the National Health System of Bhutan in 1968 with the dual objectives of providing alternative treatment for people and preserving, promoting and propagating the unique cultural and social traditions attached to this system. Despite the aromatic nature of the plants, Bhutanese make use of only few of them which are traditionally associated with our culture without proper processing.

The raw materials were collected from wild over many years resulting into steady decline of plant population. Hence, it has become increasingly difficult to collect medicinal plants from the wild. To address this situation as well as to improve the quality of the traditional drugs and to diversify the income of the rural populations, the cultivation of medicinal and aromatic plants was initiated in Bhutan in the 1990s.

From the current 11th Fiver Year Plan, all spices of medicinal and aromatic plants and essential oils have been grouped under the Spices, Medicinal and Aromatic Plants (SMAP) commodity program. The SMAP program is included as one of the commodity development program under the Horticulture Development Program of the Department of Agriculture. From the 11th FYP, SMAP has been given a commodity status and functions as one of the key horticulture commodity programs. The SMAP Program of the Department of Agriculture and Forests (MOAF) mainly focuses on high and low altitude MAP species and essential oils.

The long-term objectives of the medicinal and aromatic plants program are as follows:

- Improve the quality and availability of plant raw material for traditional medicine production
- Contribute to the conservation of medicinal and aromatic plants resources by supplementing collection with cultivation and by streamlining the collection methods
- Develop the existing commercial aromatic and medicinal plants and identify additional species with potential for commercial exploitation generating additional income for the rural people

The MAP Program in Bhutan concentrates on 3 sub-programs:

- Research on domestication of medicinal and aromatic plants
- Cultivation of medicinal plants.
- Sustainable management and conservation of MAP resources

Area, Production and Productivity

In Bhutan, most of the requirements of different medicinal and aromatic plants is largely met through collection from the wild except for a few domesticated species. The most widely domesticated species of spices, medicinal and aromatic plants (SMAP) are large cardamom (*Amomum subulatum* Roxburgh), ginger (*Zingiber officinale*), turmeric (*Curcuma longa*) and xanthoxylum (*Xanthoxylum armatum*). The domestic SMAP are mostly confined to dry sub-tropical and humid sub-tropical areas in the country.

The SMAP species that are cultivated from the wild is broadly categorized into high and low altitudes types. The natural production sites from where the high altitude MAP species are collected

are Lingtshi under Thimphu Dzongkhag, Bumthang and Haa Dzongkhags. The production sites for the low altitude MAPs are Trongsa, Mongar, Zhemgang and Samdrupjongkhar Dzongkhags. The SMAP essential oil producing species such as lemon grass are mostly produced in the four eastern districts of Mongar Trashiyangtse, Lheunetse and Trashigang. Until now, the production sites for the SMAP species collected from the wild have not been adequately mapped and demarcated.

Through the SMAP research and development programs, a small beginning has been made for the domestication of MAP species with a focus on high altitude medicinal plants. The domestication of MAP is focused in Bumthang (>2,700 m asl) and at Mongar (>1,700 m asl). The domestication of different MAP species is largely being done in the research stations at RNR Research and Development Center, Yusipang (2,700 m asl) for high altitude species and at RNR Research and Development Center at Wengkhar (1,700 m asl) for sub-tropical MAP species in the herbal gardens. Production of two important SMAP, namely, cardemom and ginger are given in Fig. 1.

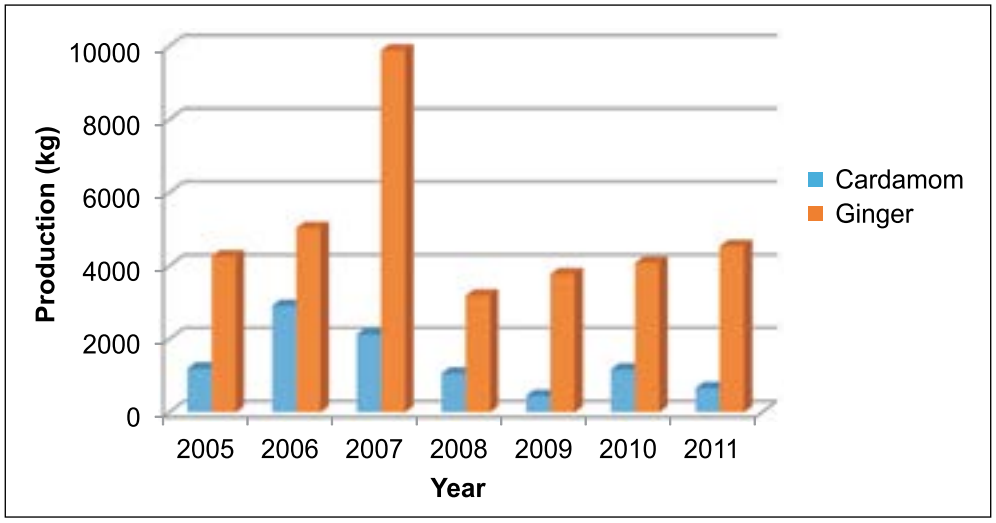

Fig. 1. *Production of two important cultivated SMAP species in Bhutan*

The production figures for most of the SMAP species are not available as they are normally collected and sold informally. The quantity sold is normally small and hence is often not recorded. The most popular SMAP species that are sold are cordyceps, large cardamon and ginger. The production and value of these three important species are given in Table 2.

Table 2. Production and value of important MAP species

Major MAP commodities	Volume (tons)				Values (Nu. Million)			
	2008	2009	2010	2011	2008	2009	2010	2011
Cordyceps	0.5	0.6	0.3	0.3	118	75	45	86
Cardamom	696	548	476	427	83	90	222	384
Lemon grass	128	0	0	1857	7	9	15	9
Total	**824.5**	**548.6**	**476.3**	**2284.3**	**208**	**174**	**282**	**479**

Source: RNR Statistics, 2012

Significant Achievements

Despite its small size in terms of human resource and area coverage, the SMAP program has made substantial achievements in the 10th Five Year Plan. the production has increased by over 66 per cent from 4,077 tons in 2007 to 6,780 tons in 2012. The export value from cardamom, cordyceps and lemon grass oil has increased from Nu. 94.2 million in 2007 to Nu. 479 million in 2012. The other major achievements are summarized below:

Germplasm collection, characterization, conservation and documentation

The research component of the SMAP program focuses mainly on the high altitude and low altitude species. The high altitude research component is based at the Renewable Natural Resources Research and Development Center (RNRRDC) at Yusipang, while the research on low altitude MAP species in coordinated from RNRRDC, Wengkhar in Mongar. The collection, characterization, selection of the provenance species and variety development are spearheading by the MAP research components. Annual field collections and surveys are regularly undertaken to improve and strengthen the genetic resource base of MAP. The repository of MAP is maintained at these two research and development centers in the country. About 124 different species of SMAP are maintained in these centers (DoA, 2011).

Through the Medicinal Plants Project phase II supported by European Union, concerted efforts were made towards laying a foundation for developing methodologies and systems for sustainable conservation and management of medicinal plants resources. To this end, mapping range and population of 16 prioritized high altitude medicinal plant species have been implemented in identified regions of Lingshi, Gangkar Punsum, Dagala and Tashi Yangtse. The species includes *Aconitum orochryseum*, *Chrysosplenium nudicaule*, *Corydalis crispa*, *Corydalis dubia*, *Dactylorhiza hatagirea*, *Delphinium glaciale*, *Fritillaria delavayi*, *Gentiana urnula*, *Meconopsis horridula*, *Meconopsis simplicifolia*, *Nardostachys grandiflora*, *Neopicrorhiza scrophulariiflora*, *Onosma hookerii*, *Rhodiola crenulata*, *Saussurea gossysipiphora* and *Veronica celiata*.

Variety development

Due to the limited technical capacity, the research on variety development, characterization and evaluation is still very limited and confined only to a few important species.

Cultivation practices

In the 10th FYP, MAP sector activities were geared towards rural poverty alleviation through increased rural income generation and enhanced livelihood. The activities included the domestication and cultivation of medicinal plants which presently cover species like ruta (*Saussurea lappa*), goned (*Carum carvi*), gurgum (*Carthamus tinctorius*), manu (*Inula racemosa*), ti-yangku (*Dracocephalum tanguiticum*), nye-shing (*Asparagus racemosus*), yonga (*Curcuma longa*)and thingye (*Zanthoxylum armatum*). These activities are implemented with the parallel objective of an improved and diversified farming system. Cultivation of medicinal plants has progressed to become a successful alternate farming venture wherein the Institute for Traditional Medicine Services (ITMS) has been the sole counterpart. Farmers produced over two million tons of MAP raw materials with corresponding earnings of Nu. 443,459.00 in 2008.

The program will continue to focus rural income generation activities through introduction of potential species and their agronomy including post-harvest practices. Research on domestication of potential species currently includes aconites (*Aconitum sp.*), goji-berry (*Lycium barbarum*), honglen (*Neopicrorhiza scrophulariiflora*), pangpoe (*Nardostachys grandiflora*), chupoe (*Valeriana wallichii*), ngyishing (*Asparagus racemosus*), thingye (*Zanthoxylum* spp.) and korean ginseng (*Panax ginseng*). Research efforts will be strengthened and expanded for which a clear and a stable mechanism should be formulated to ensure availability of quality planting materials and other inputs.

The research program has developed and disseminated the package of practices for lemon grass, *Atremisia annua,* and *Curcuma longa.* The sustainable management and conservation plans for pipla and chirata have also been developed and disseminated to the concerned stakeholders.

Production of quality seed and planting material

As most of the requirements are met from the wild collection, not much effort has been made to upscale the production of seeds and planting materials of MAP. The production of seeds and planting materials are currently limited to the Research Stations at RNR RDC Yusipang and Mongar.

Primary processing, value addition and product development

Basic processing and value addition of MAP raw or crude products are the areas on which the work has been initiated and will continue to expand upon in the areas like bio-extraction. The primary processing at present is limited to lemon grass and *Artemesia*. The processing of lemon grass oil started way back in 1997. The primary processing of lemon grass is confined to the four eastern districts of Trashignag, Trashiyangtse, Mongar and Lhunetse. The farmers who are engaged in processing, collect their raw materials from the state and community forests after paying nominal royalties to the DOFPS. The processing technology has undergone a number of assessments and at present farmers have recommended the steam distillation which is considered the most efficient. The processed lemon grass oil is sold directly by the farmers through Bio-Bhutan. Lemon grass from Bhutan has been organically certified. The Bio-Bhutan has also developed a few value added products such as the lemon grass spray and soap. The same lemon grass distillers have also embarked upon the distillation of *Artemisia*.

Product diversification and value addition has been one of the key focus areas of the SMAP program, with the financial and technical support of SNV-Netherlands. Product diversification and product development have been started at RNRRDC Wengkhar, Mongar. Farmers have been trained and technologies have been passed on to the farmer groups for making different herbal products such as soap and shampoo.

The role of the Institute of Traditional Medicines Services (ITMS) as the sole absorber of MAP has been seen as very pivotal in developing different herbal and natural products. The role of ITMS in product development and value addition thus will be very critical in the overall development of the MAP sector in Bhutan. The development of different products and

processing by the ITMS on its own could help in upscaling the production and marketing of SMAP.

Cultivation programs initiated and implemented as part of the MPPII had commendable successes but marketing has been a sticking point towards the final phase of the project. Market exploration and intelligence were found to be the crucial factors in the continuation and the long-term sustainability of the program activities. This very aspect has also been underscored as a major activity amongst others in the program's 10th FYP. The program will strive to serve the requirements of the ITMS, networking and partnership building with prospective consumers in collaboration with the Agriculture Marketing Services (AMS), both within and outside the country, and needs to be further strengthened. The placement of a MAP focal person with the AMS could be instrumental.

Disease and pest management

The cultivated SMAP species such as cardamom and ginger are seriously affected by fungal disease. The cultivation of these species are seriously threatened in most of the production sites. As these crops are cultivated by the farmers on large scale, the National Plant Protection Center (NPPC) under the DoA has initiated number of programs to address the issues of pests and diseases. On the SMAP species that are collected from the wild, not much work and initiatives have been taken up on the aspects of pests and disease management. Lack of technical capacity and limited human resource are the key limitations to start activities under this program.

Marketing, commercialization and trade

In the 10th FYP, significant achievements have been made in improving, strengthening and streamlining the marketing aspects of SMAP products and raw materials. The creation of the Department of Agricultural Marketing and Cooperatives (DAMC) under the Ministry of Agriculture and Forests has greatly facilitated the improvement of the marketing channels for all agriculture commodities including SMAP. Under the leadership of DAMC, auction of cordyceps has been streamlined and started in different production outlets like other horticultural commodities. The marketing of lemon grass oil has also been improved with the interventions from the Regional Marketing Office in Mongar.

Most of the MAP products are marketed internally in the country. The Institute of Traditional Medicine Services (ITMS) directly purchases MAP raw materials from farmers. Another private firm Bio-Bhutan, also purchases SMAP products for cosmetic related product development. Annually, it uses more than 3 metric tons of lemon grass for extraction of essential oil.

Majority of medicinal plants are exported to India while some of them like lemon grass and cordyceps are even exported to third countries like USA and European countries. The quantity and value of cardamom and cordyceps exported in 2011 are presented in Table 3.

Constraints and Opportunities

Although SMAP has been recognized as one of the key horticulture programs and accorded a high priority, there are several constraints related to the program implementation. These include:

Table 3. Quantity of important MAP species exported and value earned (2011)

Species	Country	2011	
		Quantity (tons)	Value (Nu. million)
Cardamom	Bangladesh	281.02	250.635
Cordyceps	India	145.979	133.649
	Brunei	0.007	1.901
	China	0.018	6.163
	Hongkong	0.234	64.103
	Malaysia	0.007	0.79
	Phillipines	0.002	0.699
	Singapore	0.034	12.078
	Taiwan	0.002	0.45
	USA	0.002	0.086

Source: RNR Statistics 2012

Limited technical capacity

Lack of technical capacity for research SMAP is one of the underlying constraints faced by the MAP program. Due to the lack of researchers, the research initiatives taken on SMAP are very limited. The work on variety development, production of quality seed and planting material is insufficient.

Lack of good processing facilities

Apart from lemon grass oil distillation, product development and diversification of different SMAP species is very limited. At present, ITMS and Bio-Bhutan are the only two enterprises that undertake some value addition work. Their technical capacity and demand is limited. With the opening of the Bio-prospecting Unit at the National Biodiversity Center, value addition and product diversification could pick up.

Inadequate production of seed and planting materials

The production of quality seeds and planting materials of SMAP is limited to only few domesticated species. Many interested farmers do not have access to good quality seeds and planting materials. The availability of good quality seeds and planting materials needs to be ensured in order to expand the area under cultivation of SMAP.

Lack of awareness on importance of MAP

Although more people are increasingly becoming conscious about their health and the possible negative impact of modern medicines, much remains to be done on creating awareness on the importance and use of different SMAP species. Most of MAP species are still in the hands of local practitioners and healers. There is a great scope for traditional medicines if

these can be professionally delivered through trained professionals instead of local healers and practitioners. This will encourage more farmers to venture into MAP enterprise for raw material production which will enhance rural income generation.

Uncontrolled harvesting

At present, there are no proper management plans in place for the collections of SMAP. It is a common property resource and people tend to overharvest using unsustainable practices. This could endanger some of the rare species.

Approaches for Meeting Emerging Challenges

Institutional arrangement

Spices, Medicinal and Aromatic Plants Program, a sub-program of the erstwhile Integrated Horticulture Development Project (IHDP) under the Ministry of Agriculture was until recently based in RNRRC-Yusipang, working in close coordination with RNRRC-Wengkhar (Mongar) in the planning and implementation of program objectives. It also works in close collaboration with the dzongkhag extension system and the national parks in promoting cultivation and sustainable collection. The centers at Yusipang and Wengkhar work on high and low altitude species respectively. The staff at RC-Yusipang RC-Wengkhar are inadequate and need to be strengthened.

The program which is now with the Horticulture Division will principally coordinate all national activities, while the concerned and line research centers will provide technical inputs and backstopping. The present set-up will facilitate extended and enhanced research programs and implementation of program activities in the field wherein participation and consultation with different agencies are expected to continue. Regional and international networking for information and knowledge sharing, and for collaborative and partnership building, is crucial. The program will strengthen existing networks and initiate new cooperation with regional and global organizations, viz., Medicinal and Aromatic Plants Program in Asia (MAPPA, Nepal), International Centre for Mountain Development (ICIMOD), High Altitude Plant Physiology Research Centre (HAPPRC, India), G.B. Pant Institute of Himalayan Environment and Development (GBPIHED, India), the International Society for Horticultural Science (ISHS, Belgium), etc.

Coordination, planning and reporting mechanisms

In accordance with the approved Royal Civil Service Commission (RCSC) structure for the Research System, MAP did not stand as a program in any of the four Regional Centers (RCs) in spite of the full-fledged implementation of activities in the above mentioned two RCs. The Agriculture Component of the Medicinal Plants Project (MPPII, 2004-2009) was attached with RC-Yusipang under the Council of RNR Research of Bhutan, although major portion of the project activities was extension oriented. However, this arrangement was adversely affected due to existing staff ceiling of the Horticultural Research Program, thereby impeding the progress of both the programs – an issue that raised serious concerns amongst stakeholders in consecutive coordination meetings of the National Horticulture Program.

The inception of MAP as a program with the Horticulture Division, under the Department of Agriculture, stemmed from the general consensus on the immediate need to address this constraint in staff management and resource allocation. It was also deemed timely and imperative to institute a body that could ensure the sustainability and further the interest of medicinal plant sector in the country. Besides, the upscaling of MAP to a program status also stands to provide assistance to policy makers and in creating awareness amongst stakeholders of the great resource that is available through traditional medicine and the need for it to find and maintain its proper place in public policy and government budgetary support.

The MAP program will coordinate and initiate planning of all activities with line agencies and stakeholders. Consultative planning will involve respective *dzongkhags* and research centers, including relevant agencies and will be mutually inclusive. This will ensure proper participation in activity/program planning and prevent ambiguity and possible clashes of priorities in implementation. This approach will facilitate effective communication of the national mandate of the Ministry in general and the program in particular to concerned organizations/agencies, thereby reinforcing its role as a basis for guidance in preparation of their respective plans.

Reporting on implementation status of activities is expected to follow along similar lines, wherein the chain of information would flow from the field to the RCs or the Program and finally to the Ministry, subject to the kind of activity. Information flow, however, is assumed not to be necessarily constrained to this set of sequence. It is also within an individual agency's discretion to decide on whom to feed in reports depending on the activity, but (while doing so) due emphasis should be given to bring all the concerned agencies on board.

Information management and communication system

Medicinal plants data collection has been incorporated into IMS data system and information on general cultivation programs in the field will form a part of the annual agricultural survey. Information sharing and collaboration on associated issues of concerns will continue with the ITMS who presently is the program's sole counterpart in terms of sale of produce. While dissemination of available technologies to farmers and extension personnel will follow existing service delivery systems, the program will persist with regular sourcing and archiving of technical resources, through online web searches and institutional networking. Regular training programs, workshops and seminars are seen as effective mechanisms to not only disseminate available technologies, but also to help share information and undertake productive discourse on critical issues.

Other specific agencies that the program can share and seek information and undertake collaborative initiatives towards a mutual outcome include the National Post Harvest Center (NPHC - post harvest practices), Department of Forestry (DoF-inventory/sustainable management), National Biodiversity Center (NBC - bioprospecting, intellectual property rights/traditional knowledge).

Human resources development

The Medicinal Plants Phase II Project has been able to train a number of agricultural staff within the Ministry, which includes long-term training. Even on moving forward to strengthen human capacity on aspects of MAP, it is crucial to consolidate these (existing) trained personnel under the program. An enhanced and extended research on MAP is crucial and its need has been longstanding. Placement of lead researchers in the designated research centers with corresponding support staff will be important.

Given the importance of MAP as an integral aspect of traditional and global herbal medicine system, it is necessary to strengthen professional resources in the form of human capacity and infrastructure. Staff capacity building on disciplines like agronomy, post-harvest and processing, and bio-extraction is vital. Resource development in the fields of sustainable management for stakeholders including farmer collectors should receive due credit and be implemented in the right earnest to sustain prevailing rich bio-resources.

An enabling environment has to be put in place so that workplaces can serve as breeding grounds for competent and reliable professionals. Such environments comprise placing professionals in specific positions that concur with their qualifications and interests so that one is able to build up on the strengths and grow as an individual. While multi-tasking has been an inevitable facet of the work force, it has also become increasingly necessary to redefine specific positional terms of references in order that the dividing line between professional responsibilities and other subsidiary tasks (odd job in common parlance) is not blurred. This will help boost performances. Moreover, it will also aid in restating or underscoring individuals of their own duty and of their precise roles as part of a larger workforce.

Future Thrusts

Currently, there is lack of professionally trained manpower in the field of MAP. Therefore, mainstreaming of human resources will be the immediate thrust for sustainable management of MAP program. In the 11th FYP, the MAP program will continue to be under the overall horticulture development program of the DOA. The main focus of MAP will be on increased MAP production in which production will be increased by 20 per cent from 4,354 tons in 2012 to 5,225 tons by 2018. The focus of the SMAP commodity program in the 11th Five Year Plan will be to upscale SMAP cultivation in the following potential areas:

- Improve seed and seedling production and distribution system
- Strengthen research and development activities (germplasm, nurseries and production management)
- Generation and promotion of cost-effective and safe disease management practices (e.g. cardamom blight and ginger rhizome rot)
- Establishment of storage and processing infrastructures (CFC)

Conclusion

The medicinal and aromatic plant species are under the overall purview of the Horticulture Division of the Department of Agriculture. In the current 11th Five Year Plan, it has been given a commodity program status under the Spices, Medicinal and Aromatic Plants (SMAP) commodity development program because of its significant role in supporting the livelihood of the poor rural communities.

SMAP is one of the primary source of income that supports the livelihood of the rural households, many poor households largely depend on the collection of different SMAP species to earn a living. In view of the growing acceptance of botanical medicine and plant-based industries worldwide and because of its historical significance that is associated with traditional healing

system, SMAP is gaining popularity worldwide. Due to the increasing demand, the prices are increasing which has also resulted in high export value, SMAP is also a good revenue generator in the RNR sector recognizing, the important role of SMAP, a national SMAP program has been initiated in the Horticulture Division of the DOA to coordinate all SMAP related programs and SMAP has been given a commodity program status.

The research unit for SMAP is continuously being strengthened in the RNR Research and Development Centers. Although most the SMAP requirements in the country is met from collections from the state forest, domestication of different SMAP species is continuously being done by the research program. Domestication of many species has been established in the form of herbal gardens and live herbarium at research stations and in the farmers fields. The processing, product diversification and value addition have also been initiated at research centers and these are slowly being passed on to the farmers groups as income generation rural enterprises. The marketing of SMAP has to a large extent been streamlined by the Department of Agricultural Marketing and Cooperatives (DAMC) and farmers can now sell their produce and collections through open auction organized by DAMC.

Although quite a lot has been achieved by the SMAP program, much remains to be done. Despite a huge potential of SMAP in addressing household poverty and increasing the income of the poor households, the potential remains to be fully exploited. The cultivated SMAP species such as ginger and cardamom has been seriously affected by different diseases. The germplasm evaluation and adaptation, and supply of seeds and planting materials needs to be improved and streamlined. For SMAP species collected from the wild, the focus is just on collection and sale. Much remains to be done on the sustainable management of these species and conservation of their ecosystem. The processing and value addition of SMAP is very rudimentary. Improved processing and value addition could generate better income for the rural households. Apart from the production targets, more attention has to be paid to the processing and value addition. Human capacity and infrastructure development is seen as a key area to enhance and strengthen the SMAP commodity program. As an emerging sector, the program stands to benefit from collaboration and networking with regional institutions and programs. The SMAP programs have to actively collaborative with different stakeholders to enhance the marketing of SMAP. With the window of bio-prospecting being opened up by the National Biodiversity Center, exploration and research on new SMAP species seem to be very promising in Bhutan.

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Country Status Report on Medicinal and Aromatic Plants in India

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Introduction

India has rich heritage and long history on use of medicinal and aromatic plants (MAP) as medicine, cosmetics, health hygiene, toiletries, fragrance and food supplements in improving the quality of life. India has written records of the use of plants for curing human and animal diseases which can be traced back to the earliest scriptures of Hindus (4500-1600 BC) (Ravishankar and Shukla, 2007). The Indian system of medicines (ISM) comprises of Ayurveda, Siddha and Unani which have their long roots in the society. Ayurveda is about 5,000 years old and predominantly uses medicinal and aromatic plants for their preparations and formulations. Modern pharmacopeia also listed about 25 per cent of drugs derived from plants and vast majority of synthetic analogues built on prototype compounds isolated from plants.

Three main geographical regions are present in India i.e., the rugged, mountainous Himalayan region in the northern part of the country, the Indo-Gangetic Plains and the plateau region in the southern and central part of the country. The mainland stretches from latitude 8°4'N to 37°6'N and from longitude 68°7'E to 97°25'E of Greenwich. India is the seventh largest country in the world covering an area of 32,87,590 km^2.

India's plant diversity is one of the richest in the world. It lies within the Indo-Malayan ecozone and completely hosts two of the 34 biodiversity hotspots in the world (www. Biodiversityofindia.org) and the third - Indo-Burma - lies partially within the Northeast India. India's unique geography and geology strongly influence its climate. It has six climatic zones: montane, humid sub-tropical, tropical wet and dry, tropical wet, semi-arid and arid (Köppen climate classification). Biodiversity is most abundant in the montane, humid sub-tropical and the tropical wet climatic zones. It is the home of about 7,000 medicinal and aromatic plant species (MAP) on the earth many of which have not been fully explored. Western Ghats and Himalayas are the most tempting locations for those in the bio-industries causing a serious damage to the wealth due to its overexploitation leading to depletion of resources. As per the estimates of the World Health Organization (WHO), the global herbal industry is projected to be worth US$ 5 trillion in 2050 and about 80 per cent of the world's population depends on herbal medicine for their primary healthcare. The cure of some of the deadly and painful diseases such as cancer, HIV, AIDS, rheumatic arthritis, etc. look promising through the use of herbal medicines.

There is a growing demand today for plant-based medicines, health products, pharmaceuticals, food supplements, cosmetics, etc. in the international market. The international market of medicinal plants is over US $ 60 billion per year, which is growing at the rate of 7 per cent per annum (Planning Commission, Govt. of India, 2000). The present export of herbal raw materials and medicines from India is about US $ 100-114 million per year. India is one of the major exporters of crude drugs mainly to six developed countries, viz., USA, Germany, France, Switzerland, U.K. and Japan, which accounts for 75-80 per cent of the total export market. India has registered a phenomenal growth. The export of AYUSH products has increased from INR 28,870.1 million in 2009-10 to INR 33,419.0 million in 2010-11with about 16 per cent growth rate. It has jumped to INR 190,693.9 million in 2011-12 with an annual growth rate of 471 per cent (AYUSH, 2013).

In India, MAP are consumed by herbal industries, Ayurvedic industries, Pharmaceutical industries, household usages and export. Demand is estimated to be about 319,500 tons (Ved and Goraya, 2008) of which supply comes from wild harvest from forest, roadsides, farm boundaries and water bodies; and cultivation and imports. Of 960 species of traded MAP, 178 species are consumed more that 100 tons per year and 134 species are sourced exclusively from cultivation. India's total export and import of essential oils and resinoids, perfumery, cosmetic or toiletries for the year 2012-13 was worth about US $ 1,529.84 million and 573.02 million, respectively (http://commerce.nic.in/eidb/ecom.asp).

The recent restrictions imposed on unscrupulous harvesting from forests and information of source of raw drug in the industries have made the cultivation of medicinal and aromatic plants profitable at farmers' level. There is now a broad consensus that cultivation offers the best prospect for conservation of many medicinal and aromatic plants currently found depleted in the wild. Cultivation is also seen as facilitating enhanced species identification and improved quality control, as well as species improvements in addition to maintaining or expanding supply in the market. The World Bank has observed that "while commercial cultivation of medicinal plants is taking place on a small scale, this activity is poised for 'dramatic growth' in the coming decade" and favours organic and mixed cropping to ensure 'good agricultural practices'. India is expanding its basket of cultivation of medicinal and aromatic plants by adding more and more species.

Area, Production and Productivity

Although sourcing of about 134 species are exclusively from cultivation and about 160 species are partially cultivated and also collected from the wild, yet area, production and productivity data availability of these species are far from the accuracy. There are two main reasons for non-availability of species-wise data, viz., i) species handled by the farmers and collectors are not tuned to recording of this important data; ii) land revenue department record the data under one head i.e., MAP without segregating species-wise information. However, some data available for some important crops are given in Table 1.

Table 1. Area, production and productivity of important MAP commercially cultivated in different states in India (2011-12)

Crops	Area (ha)	Productivity (kg/ha)		Production (tons)
Kerala				
Plumbago (*Plumbago rosea*)	40	10,000	(fresh root)	400.00
Aromatic ginger (*Kaempferia galangal*)	40	2,500	(dry rhizome)	100.00
Vetiver (*Vetiveria zizanioides*)	200	5,500	(root)	1,100.00
Citronella sp.	80	120	(oil)	96.00
Round-rooted galangal (*Kaempferia rotunda*)	12	10,000	(fresh rhizome)	120.00
Rajasthan				
Opium poppy (*Papaver somniferum*)	8,461	59.38	(latex)	506.00
Isabgol (*Plantago ovata*)	81,538	512	(seed)	41,721.00
Henna (*Lawsonia inermis)*	42,339	614	(leaf)	26,027.00
Bishop's weed, (*Trachyspermum ammi*)	10,753	538	(seed/fruit)	5,784.00
Fenugreek (*Trigonella foenumgraecum*)	45,138	1,208	(seed/fruit)	54,559.00
Indian Ginseng (*Withania somnifera*)	2,010	806	(root)	1,620.00
Safed musli (*Chlorophytum borivilianum*)	1,012	312	(dry root)	316.00
Rose (*Rosa* spp.)	1,100	12,000	(flowers)	13,200.00
Garden Cress (*Lepidium sativum*)	8,450	320	(seed)	2,704.00
Chhatishgarh				
Lemon grass (*Cymbopogon flexuosus*)	2,248	51,261		-
Vetiver (*Vetiveria zizanioides*)	1,022	11,987		-
Aloe (*Aloe barbadensis*)	784	7,139		-
Safed musli (*Chlorophytum borivilianum*)	293	190		-
Sweet flag (*Acorus calamus*)	148	528		-
Snakeroot (*Rauvolfia serpentina*)	29	531		-
Citronella (*Cymbopogon* sp.)	3,289	12,140		-
Indian Ginseng (*Withania somnifera*)	176	236		-
Patchouli (*Pogostemon cablin*)	200	76		-
Senna (*Senna angustifolia*)	24	26		-
Rosha grass (*Cymbopogon martinii* var *motia*)	1,631	2,939		-
Others	2,279	4,360		-
Andra Pradesh				
Aloe (*Aloe barbadensis*)	60.81	17,500	(leaf)	1,064.21
King of bitters (*Andrographis paniculata*)	120.00	2,200	(herbage)	264.00

Contd...

Table 1 (contd...)

Crops	Area (ha)	Productivity (kg/ha)		Production (tons)
Satavary (*Asparagus racemosus*)	20.00	43,750	(fleshy root)	875.00
Senna (*Senna angustifolia*)	17.54	2,000	(leaf, flower and pod)	35.09
Coleus (*Coleus barbatus*)	752.19	1,375	(Root)	1,034.26
Glory lily (*Gloriosa superba*)	8.22	3,000	(fleshy root)	24.66
Tulsi (*Ocimum sanctum*)	62.00	6,250	(herbage)	387.50
Long pepper (*Piper longum*)	1,400.00	1,500	(Fruit and root)	2,100.00
Snake root (*Rouvolfia serpentina*)	12.00	2,500	(root)	30.00
Indian ginseng (*Withania somnifera*)	1,250.73	950	(root)	1,188.19
Sweet flag (*Acorus calamus*)	2.00	8,750	(root)	17.50
Velvet bean (*Mucuna pruritens)*	83.67	2,125	(seeds)	177.80
Indian gooseberry (*Emblica officinalis*)	91.26	2,000	(fruit)	182.53
Neem (*Azadirachta indica*)	16.00	15,300	(leaf)	244.80
Ashoka (*Saraca asoca*)	269.99	-	(bark)	-

Source: State Departments/DMAPR, Anand

There are about 1,300 species of aromatic plants are available in the world and mainly used in perfumeries, flavouring industries, cosmetics, toiletries, insecticides, fungicides or as bacteriocides, solvent industries and also in aroma therapy. Mints, geranium, patchouli, lavender, chamomile, etc. are some of the exotic aromatic species which were introduced and domesticated in India and became success stories of aromatic species cultivation in India. India exports essential oils extracted from most of these species except *Citronella*, geranium, lavender, patchouli, spearmint, ylang ylang, etc. the oils of these is imported by India from other countries (Sharma *et al.,* 1996).

Because of the prevailing favourable agroclimatic conditions, India has become the major supplier of some of the mint oils to the international market. Mints are mainly cultivated in the Indo-Gangetic Plains located south of Himalayas. India is producing 75 per cent of international requirement of cornmint oil (*Mentha arvensis*) and half of the requirement of all kinds of mint oils (Singh *et al.,* 1999). Cornmint is cultivated over 125,000 - 175,000 ha of land in India. The other important mint species cultivated in India are *M. spicata*, *M. piperita*, and *M. gracilis*.

Major Uses

The MAP species mainly used as raw drugs in trade are consumed by the manufacturing industries engaged in preparing formulations under different systems of medicines such as Ayurveda, Unani, Siddha, folk, herbal, Tibetian and western medicines. An analysis of 960 highly traded MAP in India across different medicine systems are presented in Table 2.

Table 2. Traded MAP in India and their use in different systems of medicines (Ved and Goraya, 2008)

System	Ayurveda	Folk	Homoeopathy	Siddha	Tibetian	Unani	Western
Ayurveda	688	480	129	461	198	307	50
Folk	480	651	104	422	167	248	46
Homeopathy	129	104	146	104	60	99	42
Siddha	461	422	104	501	176	254	41
Tibetian	198	167	60	176	197	153	21
Unani	307	248	99	254	153	328	42
Western	50	46	42	41	21	42	67

Different parts of the MAP species are used in trade. Part-wise break-up of about 1289 botanicals in trade in India is presented in Table 3. About 2/3rd of the species are harvested using destructive harvesting which is a major concern for conservation and also for sustainability.

Table 3. Part-wise break-up of the traded MAP used in medicinal systems in India (Ved and Goraya, 2008)

Plant parts /products	Number of species	Percentage
Roots	338	26.2
Fruits	333	25.8
Whole plants	168	13.0
Stems and barks	162	12.6
Leaves	140	10.9
Flowers	84	6.5
Exudates (gums and resins)	37	2.9
Wood	20	1.6
Galls	4	0.3
Oil	3	0.2
Total	**1289**	**100**

In addition, MAP species are also used for various other purposes by various industries as follows:

- As raw material for extraction of aroma chemicals, essential oils and other natural extracts, fragrances and flavours
- As raw material for cosmetics, health hygiene, toiletries and food supplements
- Also consumed as vegetables, spices and condiments.

Major Organizations Working on MAP

Systematic work in the crop improvement of medicinal plants is being carried out at national level

under Indian Council of Agricultural Research through its Directorate of Medicinal and Aromatic Plants Research (DMAPR) and All India Coordinated Research Project on Medicinal and Aromatic Plants and Betelvine (AICRP on MAP&B) centres situated in State Agricultural Universities and Council of Scientific and Industrial Research (CSIR) through Central Institute of Medicinal and Aromatic Plants (CIMAP) and various Regional Research Organizations situated in different parts of India. In addition, a number of organizations are also working in different states as Government and voluntary non-governmental organizations. In addition to this, National Bureau of Plant Genetic Resources (NBPGR) initiated work on MAP and now acts as nodal agency for the collection, characterization, documentation and maintenance of medicinal and aromatic plants.

Significant Achievements

Germplasm collection

Plant genetic resources (PGR) are the basic raw material for genetic improvement and varietal development. In medicinal plants wild species play an important role. About 90-95 per cent species are collected from forests or its wild habitat. Utilization of national heritage of medicinal plant resources should, therefore, be planned in such way that it must conserve the MAP as well as it should bring out the maximum potential of resources to ensure a healthy and prosperous future generation. India will play a key role at the international level also, if medicinal plant genetic resources are to be properly managed.

Collection of vast diversity of germplasm is the key to the success of development of superior variety of medicinal plants. Chomchalow (1980) reported the importance of genetic resources in the improvement of medicinal plants. The potential of the germplasm has not yet been fully utilized in MAP. like any other crop, cultivation of medicinal plants started with the direct introduction of the species from the wild habitat to agriculture.

Germplasm characterization

The second and foremost step after collection is characterization of the germplasm. Value of any germplasm is known once it is characterized. Role of plant breeding to select best plants within the variable population as a potential cultivar to increase yield manyfold. The potential productivity of cereal crops has traditionally been increased by modifying its morphological characters such as number of branches, number of kernels per ear, test weight of seeds, etc. But, in medicinal and aromatic plant improvement, it is entirely different from other agricultural crops, because quality in terms of alkaloid, steroid or essential oil is not apparently dependant on morphological characters. All the breeding objectives and selection criteria should, therefore, be directed to enhance the total secondary metabolite content and biomass production in a particular crop species. Simple introduction of a variety for successful cultivation in a new environmental condition may some time be futile due to chemical changes and infra-specific chemical modifications, which may take place due to, altered ecological and geographical conditions (Tetenyi, 1992).

Characterization data are available in DMAPR, CIMAP and SAUs on vast majority of MAP such as *Aloe barbadensis, Andrographis paniculata*, *Bacopa monnieri, Chlorophytum borivilianum, Cymbopogon martinii var motia, Gymnema sylvestre, Mucuna pruriens, Papaver somniferum, Plantago ovata*, *Pelargonium graveolans, Gloriosa superba, Piper betle, Withania somnifera, Solanum nigrum, Swertia chirayita, Plumbago zeylanica, etc.*

Germplasm conservation

Ex situ conservation of medicinal plants has been initiated at national and state levels. National Bureau of Plant Genetic Resources (NBPGR) acts as nodal agency for the collection and maintenance of medicinal plants. Under All India Coordinated Research Project on Medicinal and Aromatic Plants and Betelvene (AICRP-MAP), since its inception, constant efforts are being made for collection and evaluation of germplasm in selected MAP. At present, there is a total of 2,402 germplasm accessions (Table 4) in different medicinal and aromatic plants maintained at various AICRP-MAP centers including its headquarters at the Directorate of Medicinal and Aromatic Plants Research (DMAPR). Similar efforts are also being made for collection of selected medicinal plant biodiversity from their wild habitats by the Central Institute of Medicinal and Aromatic Plants (CIMAP) and other institutions engaged in MAP research, viz., NBPGR. At present, NBPGR conserves 6,845 accessions of different MAP species (http:// www.nbpgr.ernet.in/ Research_Projects/Base_Collection_ in_NGB.aspx).

Table 4. Germplasm status of MAP in field gene bank

Species	**Accessions maintained**		
	DMAPR	**AICRP (MAP)**	**Total**
Aloe (*Aloe* spp.)	55	169	224
Ashwagandha (*Withania somnifera*)	142	523	665
Betelvine (*Piper betle*)		278	278
Giloe (*Tinospora cordifolia*)	52	39	91
Guggul (*Commiphora wightii*)	175	49	224
Psyllium (*Plantago ovata*)	85	292	377
Kalmegh (*Andrographis paniculata*)	60	59	119
Lemongrass/Palmarosa (*Cymbopogon spp*)	07	147	154
Senna (*Senna angustifolia*)	120	17	137
Safed musli (*Chlorophytum borivilianum*)	54	79	133
Total	**750**	**1,652**	**2,402**

Source: DMAPR Annual Report 2012-13

A number of elite lines/unique genotypes lines were selected and registered as elite germplasm stocks at NBPGR (Table 5).

Using the current global rate of species extinction, about 10-12 per cent of the country's medicinal plants (800-1,000 species) are likely to be threatened. Considering the stress on the medicinal plant wealth, Government of India passed the Foreign Trade Development and Regulation Act in 1992. This law and related legislation now requires all companies to declare the source of their raw material and prohibits the export of 29 different plants (Box 1), plant portions, their derivatives and extracts if obtained from wild sources. The IUCN report for the year 2,000 revealed that India ranked fifth in case of threatened plant species and birds. Recently, some rapid assessment of the threat status of medicinal plants using IUCN

Box 1. List of plants prohibited for trade by Govt. of India

Aconitum sp.	*Euphorbia sp.*	*Picrorhiza kurrooa*
Aquilaria malaccensis	*Frerea indica*	*Podophyllum hexandrum*
Ceropegia sp.	*Gentiana kurroo*	*Pterocarpus santalinus*
Coptis teeta	*Gnetum sp.*	*Rauvolfia serpentina*
Coscinium fenestratum	*Kaempferia galanga L.*	*Renanthera imschootiana*
Cyathea sp.	*Nardostachys grandiflora*	*Saussurea costus*
Cycadaceae sp.	*Nepenthes khasiana*	*Swertia chirayita*
Cycas beddomei	*Orchidaceae sp.*	*Taxus wallichiana*
Dactylorhiza hatagirea	*Panax pseudoginseng*	*Vanda Coerulea*
Dioscorea deltoidea	*Paphiopedilum sp.*	

(Source: BSI data (http://164.100.52.111/search1species.asp?cc=2)

Table 5. List of elite genotypes/genetic stocks registered at NBPGR

Crop	No. of entries	Crop	No. of entries
Aloe (*Aloe barbadensis*)	03	Kalmegh (*Andrographis paniculata*)	02
Ashwagandha (*Withania somnifera*)	02	Kawaunch (*Mucuna pruriens*)/(*Mucuna utilis*)	03
Babchi (*Psoralea corylifolia*)	01	Mandukparni (*Centella asiatica*)	01
Betelvine (*Piper betle*)	01	Oregano (*Origanum vulgare*)	02
French lavender/ camphor lavender (*Lavandula stoechas*)	02	Nepalese kutki (*Picrorhiza scrophulariiflora*)	01
Gilo (*Tinospora cordifolia*)	01	Opium poppy (*Papaver somniferum*)	01
Greater galangal (*Alpinia galanga*)	02	Rose geranium (*Pelargonium graveolens*)	02
Indian bedellium (*Commiphora wightii*)	02	Safed musli (*Chlorophytum borivilianum*)	02
Gymnema (*Gymnema sylvestre*)	01	Soapnut (*Sapindus mukorossi*)	01
Indian valerian (*Valeriana jatamansi*)	01	St. John's Wort (*Hypericum perforatum*)	03
Isabgol (*Plantago ovata*)	02		

designed CAMP methodology revealed that about 112 species in Southern India, 74 species in Northern and Central India and 42 species in high altitude of Himalayas are threatened in the wild. Therefore, this new regulatory environment has opened up new market opportunities for small-scale farmers, if they can be made aware of these new market opportunities and then acquire the necessary production technologies to successfully produce different MAP species to market specification. Thus, conservation and sustainable utilization of medicinal plants is a major concern in the present situation. The best way to conserve the medicinal plants as in the case of any other taxa is *in situ* conservation and in some rare cases if the habitat is threatened, selected species can be saved through *ex situ* conservation.

In India, no separate policy or regulation exists for conservation of medicinal plants. Their conservation is mainly covered under the India Forest Act (1927) and Wild Life Protection Act (1972), which are enforced by the State Forest Departments and Indian Government's Directorate of Wildlife Preservation. The first *in situ* conservation project for the conservation of medicinal plants in India was initiated in the states of Karnataka, Kerala and Tamil Nadu involving the State Forest Departments, leading NGOs and Research Institutes in 1993 in collaboration with Foundation for Revitalization of Local Health Traditions (FRLHT) - a Bangalore based NGO group. This project, sponsored by the Govt. of India, developed a network of medicinal plant conservation sites (MPCS), medicinal plant conservation parks (MPCP) and medicinal plant development sites (MPDS). Apart from, there are national parks, biosphere reserves and world heritage sites.

Indigenous communities develop their own ways for the conservation of natural resources. One of such conservation practices is the 'sacred groves'. These are areas which are devoted to Gods and Goddesses and are strictly protected from human interference. It can be considered as the first human effort for the *in situ* conservation of biodiversity. But in the present age, these great traditions are also facing a lot of threats because of the change in values, living styles, etc. and the number of such *in situ* conservation sites is declining.

Seed gene bank (NBPGR), *in vitro* gene bank (NBPGR), field gene banks (NBPGR, ICAR institutes and SAUs), botanical and herbal gardens (SAUs, NGOs, schools, community lands), etc. are the different types of *ex situ* conservation methods followed in India. Rare, unique, and native plants can be preserved as living collections.

Development of varieties

Improved varieties are the products of plant breeding efforts. However, it did not find acceptance in totality for improvement of MAP. The obvious reason for low acceptance is the lack of understanding on mode of action of majority of medicinal plants that are used in Ayurvedic preparations. In most of the cases, there is no single bio-active molecule but a battery of various groups of chemicals such as flavoinoids, alkaloids, glycosides, terpinodes, phenols, etc. which synergistically produce the curative result. Their proportion is also important. Plant breeding for quality improvement in terms of increasing the percentage of these chemicals are possible only when the medicinal plants are used for extraction of specific chemicals such as sennoside from senna; morphine from opium poppy; quinine from *Cinchona*; artemisin from *Artemisia*. But, when breeding of medicinal plants used in Ayurveda, Siddha, and Unani medicines is concerned, it becomes difficult to set the breeding objectives. Problem of setting the breeding objectives in terms of increasing the quality of a particular constituent will not be accepted because it will upset the dosages prescribed and also efficacy will be altered. Therefore, every new cultivar of particular species has to be supported by further standardization of either dosage or quantity of the species in a codified Ayurvedic drug which will jeopardise the entire Ayurvedic, Siddha and Unani medicines preparation.

Therefore, at present the scope of plant breeding efforts in these groups of plants are limited to disease and pest resistance and yield improvement without compromising the initial quality in terms of chemical constituents. This is also a grey area to the researchers since there is no base value in terms of bio-active molecules available in various species of plants that have been considered as quality material in Ayurvedic preparations. So far, Ayurvedic industry demands only right species with clean material as quality standard. Therefore, there is a need

for concerted efforts to identify species-wise quality parameters before taking up any serious breeding programme in MAP that are used for Ayurvedic medicines. However, a number of cultivars developed by various institutions are given in Tables 6 and 7.

Table 6. List of MAP varieties developed by ICAR (AICRP-MAP)

S. No.	Crop	Variety	S. No.	Crop	Variety
Medicinal Crops					
1.	*Andrographis paniculata*	Anand Kalmegh 1 (AK 1)	12.	*Rauvolfia serpentina*	RI 1
2.	*Cassia angustifolia*	Anand Late Selection	13.	*Papaver somniferum*	Jawahar Aphim 16, Kirtiman, Jawahar Opium 539, Jawahar Opium 540, Chetak Aphim, Trishna
3.	*Catharanthus roseus*	Prabhat	14.	Piper betle	Bidhan Pan, SGM 1, SGM 2, Swarna Kapoori
4.	*Chlorophytum borivilianum*	Jawahar Safed musli 405, Raj Vijay Safed musli 414 (RVSM 414)	15.	*Piper longum* L.	Viswam
5.	*Centella asiatica*	Vallabh Medha	16.	*Plantago ovata*	Gujarat Isabgol 1, Gujarat Isabgol 2, Gujarat Isabgol 3, Haryana Isabgol 5, Jawahar Isabgol 4
6.	*Diascoria floribunda*	FB(C) 1, Arka Upakar	17.	Solanum laciniatum	NH 88-12
7.	*Digitalis lanata*	D 76	18.	*Solanum viarum* (*S. khasianum*)	Arka Sanjeevani, Arka Mahima
8.	*Glaucium flavum*	H 47-3	19.	*Withania somnifera*	Jawahar Asgand 20, Jawahar Asgand 134, Raj Vijay Aswagandha 100 (RVA 100)
9.	*Glycyrrhiza glabra*	Haryana Mulhatti 1	20	*Senna angustifolia*	Anand Senna 1 (AS 1)
10.	*Hyoscyamus muticus*	HMI-80-1	21.	*Saraca asoca*	Aswani 1
11.	*Lepidium sativum*	GA 1			
Aromatic crops					
1.	*Cymbopogon flexuosus*	NLG-84	4.	*Mentha spicata*	Punjab Spearmint 1
2.	*C. martinii* Var. motia (Palmarosa)	Rosha Grass 49, CI-80-68	5.	*Valeriana jatamansi*	Dalhousi Clone
3.	*Jasminum grandiflorum*	Arka Surabhi	6.	*Vetiveria zizanioides*	Hy 8

Table 7. MAP varieties developed by CIMAP (1998-2013)

S. No.	Crop	Variety	S. No.	Crop	Variety
Medicinal crops					
1.	*Acorus calamus*	CIM-Balya	11.	*Hyocyamus niger*	Aekla
2.	*Andrographis paniculata*	CIM-Megha	12.	*Lippia alba*	Kavach
3.	*Aloe vera*	CIM-Sheetal	13.	*Mucuna pruriens*	CIM-AJAR
4.	*Bacopa monnieri*	Subodhak, Pragyashakti, CIM-Jagriti	14.	*Papaver somniferum*	Rakshit, CIMAP Ajay
5.	*Cassia angustifolia*	Sona	15.	Phyllanthus amarus	Navyakrit
6.	*Catharanthus rosea*	Prabal	16.	*Plantago ovata*	Neeharika
7.	*Centella asiatica*	Kayakrit, Majjaposhak	17.	*Rauvolfia serpentina*	CIM-Sheel
8.	*Commiphora wightii*	Marusudha	18.	*Salvia sclarea*	CIM-Chandni
9.	Foeniculum vulgare	CIM-Sujal of Fennel	19.	*Stevia rebaudiana*	CIMAP Mdhu
10.	Glycyrrhiza glabra	Mishree	20.	*Withania somnifera*	Poshita, Selection
Aromatic crops					
1.	Artimesia annua	Jeevanraksha, Sureksha, CIM-Arogya	10.	*Mentha sp.*	Neerkalka, Cim-saumya, Vikarshudha, Kusumohak, MC 05
2.	*Chamomilla recutita*	Prashant, CIMAP Sammohak	11.	*Ocimum basilicum*	EL 04
3.	*Cymbopogon flexuosus*	Krishna, Chirharit	12.	*Ocimum sanctum*	CIM-Angana
4.	*Cymbopogon khasianum*	CIM- Suwarna	13.	*Ocimum tenuiflorum*	Kanchan
5.	*Cymbopogon martinii*	Vaishnavi, Trishna, Tripta, PRC 1, CIMAP Harsh	14.	*Pogostemon patchouli*	CIM-Samarth
6.	*Cymbopogon winterianus*	Manjari, Jalpallavi, CIM-Jeeva	15.	*Pelargonium*	Clone No. 53, Clone No. 79
7.	Mentha arvensis	Himalaya, Kosi, Damroo, Saksham, Sambhav	16.	*Rosa damascens*	Ranisahiba
8.	Mentha piperita	Pranjal, CIM-Madhuras, CIM-Indus	17.	*Tagetus minuta*	Vanaphool
9.	*Mentha spicata*	Ganga	18.	*Vetiveria zezanioides*	Dharini, Gulabi, Kesari, CIM-Vriddhi

Cultivation practices

Cultivation of medicinal and aromatic plants in a limited scale and in limited species started in the beginning of the 19th century but large scale cultivation with large number of species is a recent phenomenon. Cultivation of medicinal and aromatic species gives scope to improve the quality of the drugs. Merits of commercial cultivation of MAP is the outcome of implementation of number of critical factors like good genetically stable planting materials; good agro-technological practices; nutrient input; harvesting management and implementation of suitable post-harvesting techniques to preserve the end product till smart and effective marketing arrangements are made. At present, National Medicinal Plants Board (NMPB) is promoting 32 species for large scale cultivation (Table 8).

Table 8. List of medicinal plants identified by National Medicinal Plants Board for development and cultivation on priority

S. No.	Crop	S. No.	Crop
1.	Ashoka (*Saraca asoca* (Roxb.)de. Wilde.)	17.	Kalmegh (*Andrographis paniculata* L.)
2.	Ashwagandha (*Withania somnifera* Dunal)	18.	Kuth (*Saussurea costus* C. B. Clarke.)
3.	Atis (*Aconitum heterophyllum* Wall.)	19.	Kutki (*Picrorhiza scrophulariflora* Pennell. /*P. Kurrooa*)
4.	Bael (*Aegle marmelos* L. Corr.)	20.	Liquorice (*Glycyrrhiza glabra* Linn.)
5.	Black nightshade (*Solanum nigrum* Linn.)	21.	Malabar tamarind (*Garcinia indica* Linn.)
6.	Brahmi (*Bacopa monnieri* (L.) Pennell)	22.	Psyllium (*Plantago ovata* Forsk.)
7.	Chandan (*Santalum album* Linn.)	23.	Saffron (*Crocus sativus* Linn.)
8.	Chiraita (*Swertia chirata* Buch-Ham.)	24.	Satavari (*Asparagus racemosus* Willd.)
9.	Coleus (*Coleus barbatus* Benth./ *C. vettiveroides* Jacob)	25.	Safed musli (*Chlorophytum arundaenaceum* Baker)
10.	False black pepper (*Embelia ribes* Burm. F)	26.	Sarpgandha (*Rauvolfia serpentina* Benth. Ex. Kurz.)
11.	Glory lily (*Gloriosa superba* Linn.)	27.	Senna (Sanai) (*Senna angustifolia* Vahl.)
12.	Gymnema (*Gymnema sylvestre* R. Br.)	28.	Stone breaker (*Phyllanthus amarus* Schum. and Thonn. (*P. niruri* Linn.)
13.	Indian aconite (*Aconitum ferox* Wall)	29.	Tinospora (*Tinospora cordifolia* Miers.)
14.	Indian bellidium (*Commiphora wightii* (Arn.) Bhant.)	30.	Tulsi (*Ocimum sanctum* Linn./*O. basilicum*)
15.	Indian gooseberry (*Emblica officinalis* Gaertn.)	31.	Long pepper (*Piper longum* Linn.)
16.	Jatamansi (*Nardostachys jatamansi* DC.)	32.	Wood turmeric (*Berberis aristata* DC)

In recent decades, there have been a number of widely publicized cases of consumers suffering with adverse health effects caused by poor quality herbal medicines. In many of these cases, the cause of the problem has been linked to the quality of the raw material used for medicine preparations.

The growing demand for herbal products has also led to over-harvesting from the wild, causing concern over the long-term environmental impact and availability of certain medicinal plant species if they are not collected in a responsible manner. As a result of these concerns, the herbal industry has come under increasing pressure to provide consumers with assurance that herbal products in the market are safe to use and do not have a negative impact on the environment. Some governments have responded to this pressure by creating new laws, requiring herbal manufacturers to adhere to stricter regulations, both in the manufacture of medicines as well as in the sourcing of raw materials.

The call for greater quality assurance has highlighted the need to improve the quality standards of the medicinal plant growers, collectors and processors. It is in this context that WHO developed the GACP guidelines, which various governments have subsequently adopted with minor modifications as per the regional requirement. NMPB in India also developed a set of guidelines for good agricultural and field collection practices in 2009 and subsequently certification criteria as a voluntary certification scheme were launched in 2012. Below is a summary of some the key concerns that are addressed by the GACP guidelines:

***Hygiene and cleanliness*:** It is alarmingly common for medicinal plant materials to be contaminated with microbes such *Escherichia coli* (*E. coli*) or *Salmonella*, which is usually due to basic lack of hygiene and cleanliness during harvest and primary processing. Preventing microbial contamination through improved hygiene and cleanliness is, therefore, a central theme throughout the GACP guidelines.

***Prevention of contamination*:** Medicinal plant material can come into contact with many sources of contamination during transportation from field to shelf. Risk of contamination with heavy metals, pesticides and other chemicals is of serious concern. If any of these contaminants do find their way into herbal medicine products, they can cause adverse effects on the health of the consumer.

***Identification*:** There have been a number of cases in recent years in which incorrect plant species have been used in herbal medicines, leading to adverse effects on health of the consumer. GACP places emphasis on ensuring that medicinal plants are correctly identified and that systems are in place to provide buyers with assurance that they are buying the material of right species.

***Efficacy*:** If medicinal plants are not cultivated in a suitable environment and are harvested at the wrong time of year or if they are processed incorrectly, the potency of the medicinal properties may be reduced, leading to the manufacture of ineffective herbal medicines. GACP guidelines explore the main principles that should be followed by farmers and collectors to ensure that they are producing medicinal plant materials with maximum levels of active ingredients.

***Yield*:** Wrong agricultural and collection practices not only affect the end quality of the herbal medicines, but they can also reduce the yield and income of the farmers and collectors. GACP aims to provide guidance to farmers and collectors on how to optimize both quality and yield of medicinal plant materials.

***Sustainability*:** Increasing number of medicinal plant species are becoming threatened or endangered due to unsustainable collection methods in the wild. One of the key themes of the GACP guidelines is to ensure that medicinal plants are collected in a manner that

allows the plants to regenerate year after year. In this way, long-term survival of plants will be ensured, the medicinal plant collectors will have a regular source of income, and the herbal industry will have a long-term supply of medicinal plant materials for manufacturing herbal medicines.

***Documentation and traceability*:** If medicinal plant growers and collectors do not keep records of their activities, it is impossible to trace the medicinal plant material back to its origin. Traceability is an essential part of GACP; it means that problems can be traced back to where they occurred and measures can be taken to prevent it from happening again. Traceability is made possible by documentation, and therefore, documentation is a recurring theme throughout the GACP guidelines.

***Social and legal concerns*:** The large majority of medicinal plants are still collected from the wild. This means that the plants are usually collected from land that is either owned by the local community or by the government (or a combination of the two) and is subject to a variety of local, national and international rules and regulations. With increasing competition for limited resources the medicinal plants in these collection areas are coming under growing pressure. The GACP guidelines stress the importance of adhering to both the traditional collection rules as well as the relevant government laws so common resources can be managed in a sustainable manner and the medicinal plants continue to be available for the local communities to collect for their own household use.

Good agricultural practices (GAP) are available for several medicinal and aromatic plants (Box 2) and the rest are in various stages of research and will be made available as soon as finalized. However, organic cultivation is also practiced for some of the important medicinal plants such as *Ocimum sanctum, Asparagus racemosus,* etc. Under no circumstances, bad agricultural practices such as indiscriminate use of pesticides, inorganic fertilizers, city waste, night soil, etc. are permitted for cultivation of medicinal and aromatic crops.

Box 2. GAP available for MAP in India (DMAPR and CIMAP)

Medicinal plants

Aloe (*Aloe barbadensis*), Asparagus (*Asparagus racemosus*), Betelvine (*Piper betle*), Black nightshade (*Solanum nigrum*), Indian ginseng (*Withania somnifera*), Indian pennywort (*Centella asiatica*), Indian whitehead (*Enicostemma axillare*), King of bitters (*Andrographis paniculata*), Psyllium (Plantago ovata), Safed musli (*Chlorophytum boriviianum*), Tulsi (*Ocimum sanctum*)

Aromatic plants

Geranium (*Pelargonium graveolens*), Lemongrass (*Cymbopogon flexuosus*), Palmarosa (*Cymbopogon martinii var. motia*), Patchouli (*Pogostemon cablin)*, Sweet wormwood (*Artemisia annua*), Vetiver (*Vetiveria zizanioides*)

Pest management

The pest (insect pests and diseases) management in MAP is aimed to minimize the pressure of pesticide residues in the herbal products. The integrated pest management (IPM) strategies are the best choice for MAP and include cultural practices (eg: change of sowing date, crop

rotation to break pest life cycle, soil pulverisation), mechanical control measures (eg: collection and destruction of adults and young ones, use of different types of traps for monitoring and management of insect pests), cultivation of pest resistant varieties under field condition, use of botanicals (eg: *neem* based pesticides), use of biocontrol agents (e.g. *Trichogramma* sp. as egg parasitoid of lepidopteran pests, antagonistic microorganisms against plant pathogens, *Trichoderma* spp.), use of microbial insecticides (e.g. use of *Bacillus thuriengenesis*, nuclear polyhedrosis virus against various caterpillar pests and use of entomopathogenic fungi like *Beauveria bassiana, Verticillium lecanii* against insect pests) and other biorational approaches like use of insect growth regulators (IGR), pheromone traps, etc. But under GAP cultivation, pesticides are allowed in extreme cases to save the crop from total failure. However, care should be taken to harvest the crop or sending the produce to the market only after the prescribed safe waiting period is over. Important pests encountered in cultivation of some of the MAP are given in the Table 9.

Production of quality seed and planting material

Cultivation recognizes the need for good seed as the first input to grow healthy crop and to get a good return. Therefore, seed of improved cultivars are in constant demand for increasing yield as well as quality in terms of nutrition, active principles, pest resistance, etc. Demand for seed and planting material of released cultivars of medicinal and aromatic plants is erratic, irregular and in low volume, and as a result the seed and planting material supply industry as well as seed supply chain are not fully geared up to support this sector. At present, research organizations are identifying the elite cultivars and releasing either at their institute level or through Central Varietal Release Committee. Ofcourse, recently Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA) has started developing Distinctiveness, Uniformity and Stability (DUS) descriptors and is ready for registration of *Plantago ovata*, *Bacopa monnieri, Allium sativum*, *Catharanthus roseus, Piper nigrum*, *Curcuma longa*, *Zingiber officinale, Mentha arvensis* and *Rosa damascena*. Efforts are continuing to include more and more species under PPVFRA registration domain. Present seed chain in MAP is from research organizations to farmers. Certification of MAP seeds is not in vogue at present. This is creating problem in maintenance breeding and availability of high quality seeds and propagating material of notified varieties ensuring their genetic identity and genetic purity at all time.

There are many MAP species cultivated at only species level. Industries requirement so far is only genuineness of the species. Therefore, many private seed and planting material nurseries are supplying the seed and planting material. A large quantity of seed and planting material supply of MAP species is through the herbal gardens created by many organizations. A national effort has been made by the Directorate of Medicinal and Aromatic Plants Research with the funding from NMPB to connect the herbal gardens through an e-portal (www.harbalgardensindia.org) which provides availability of genuine seed and planting material of MAPs among the member herbal gardens across India.

Different types of reproduction and seed/planting material used in MAP are as follows:

- Sexual reproduction - True seed
- Asexual reproduction

Table 9. Important pests associated with cultivation of some of the MAP species

S. No.	Medicinal plant	Insect pests	Diseases
1.	Aloe (*Aloe barbadensis*)		Soft rot (*Pectobacterium chrysanthemi*)
2.	*Aonla* (*Emblica officinalis)*	Leaf roller (*Gracellaria acidula*) Fruit borer (*Dueodorix isocrates*) Fruit moths (*Otheris fullonica*, *O. materna*) Bark borer (*Inderbala tetronis*)	Aonla rust/ ring rust (*Ravenalia emblicae*) Fruit rot (*Pencilium oxalicum*)
3.	Ashwagandha (*Withania somnifera*)	Hadda beetle (*Epilachnavigintii octopunctata*) Fruit borer (*Helicoverpa armigera*)	Leaf spot (*Alternaria alternata*) Phyllody (Phytoplasma)
4.	Black nightshade (*Solanum nigrum*)	White fly (*Bemissia tabacci*) Red spider mite (*Tetranychus* sp) Cotton aphid (*Aphis gosyppii*)	
5.	Forskohli (*Coleus forskohlii*)	Tingid bug (*Monantha globulifera*) Spike borer (*Helicoverpa armigera*)	Root rot (*Rhizoctonia bataticola*)
6.	Guggal (*Commiphora wighitii*)	Termites (*Microtermes* sp)	Leaf spot (*Phoma glomerata*, *Cercospora* sp.)
7.	Henna (*Lawsonia inermis*)	Semilooper (*Achoeae janata*)	
8.	Lemon grass (*Cymbopogon flexuosus*)	Termites (*Microtermes* sp)	
9.	Opium poppy (*Papaver somniferum*)	Poppy root weevil (*Ceuthorynchus deticulatus*, *C. macula alba*) Green Peach Aphid (*Myzus persicae*)	Powdery mildew (*Erysiphe polygoni*) Downy mildew (*Pernospora arborescene*) Root rot (*Cylindrocladium* sp.)
10.	Palmarosa (*Cymbopogon maritinii* var. motia)	Termites (*Microtermes* sp)	
11.	Psyllium (*Plantago ovata*)	Cotton aphid (*Aphis gossypii*)	Downy mildew (*Pernospora plantaginis*)
12.	Safed musili (*Chlorophytum borivilianum*)	Snout beetle (*Crytozemia dispar*)	
13.	Senna (*Senna angustifolia*)	Tropical pierid butterfly (*Catopsilia pyranthe*)	Leaf blight (*Alternaria alternata*) Damping-off (*Macrophomina phaseolina*)
14.	Tulsi (*Ocimum sanctum*)	Lace wing bug (*Cochilochila bullita*)	

- Vegetative propagation-rhizome, bulb, etc.
- Apomixis
  - Vegetative proliferation- bulbils
  - Agamospermy (gametophytic apomixis; adventitious embryony)

Primary processing, value addition and product development

Farmers and collectors of medicinal and aromatic plants have history of selling products as sourcing material sometime even without drying at the lowest market level. Therefore, such raw material fetch minimum possible price, which is often not enough to sustain the production cost. Under such circumstances, value addition is the only answer for economic survival of production as well as the sustainable supply of the sourcing material. Value addition means, anything that is done to raise the value of the product in the market. The value added practices are going to be the key for the future of sustainable farming, since it enables the growers to advance economically without targeting the unsustainable increase in productivity from the land. Value added medicinal and aromatic plant products may range from simple processes such as drying, grading, grinding, and cleaning to very sophisticated processes such as spray drying, vacuum drying, fractionation of molecules, etc.

In medicinal plants, first level value addition can be even GACP, organically or bio-dynamically certified products, which can fetch straight away upto 30-60 per cent premium price. This would be common for all the cultivated species. Possible primary processing and value addition activities for selected individual crops are as follows:

Psyllium (*Plantago ovata*): Usually the seeds are sold as such by the farmers. The usual value addition practice for export is as follows: (i) cleaning of seeds from clay and other foreign material, and (ii) separation of seed coat and grading

Aswagandha (*Withania somnifera*): Root is sold in the market. Processing and value addition include: (i) making into pieces, (ii) cleaning and grading based on diameter, and powder making.

Aloe (*Aloe barbadensis*): Gel present in the leaf is of major demand in the market. Extraction of the gel, stability maintenance of the gel and powder making are important steps.

Senna (*Senna angustifolia*): Dry leaves are sold in the market. Processes and value addition include: (i) mechanical drying through hot draft of air or solar drying, and (ii) grading of leaf based on size and colour.

Safed musli (*Chlorophytum borivilanum*): Dried root is sold in the market. The steps for processing and value addition include: (i) peeling of the fresh root, and (ii) drying.

Satavary (*Asparagus racemosus*): Dried root is sold in the market. The steps for processing and value addition include: (i) cleaning, and (ii) drying and chopping.

Kalmegh (*Andrographis paniculata*): Dried herbage is sold in the market. The steps for processing and value addition include: (i) cleaning, (ii) drying and chopping, and (iii) making powder/ herbal concentrate.

Glory lily (*Gloriosa superba*): Dried seeds and roots are sold in the market. The steps for processing and value addition include: (i) cleaning, (ii) drying, and (iii) colchicine extraction and concentration.

Lemongrass (*Cymbopogon flexuosus*): The steps for processing and value addition include: (i) essential oil extraction from the herbage, and (ii) fractional distillation.

Palmarosa (*Cymbopogon martinii* var. *motia*): The steps for processing and value addition include: (i) essential oil extraction from the herbage, and (ii) fractional distillation.

Marketing Chain of MAP

Raw drugs marketing chain (Fig. 1) can be classified into different categories based on annual transactions turnover by volumes of botanicals traded as well as type of transactions (Ved and Goraya, 2008).

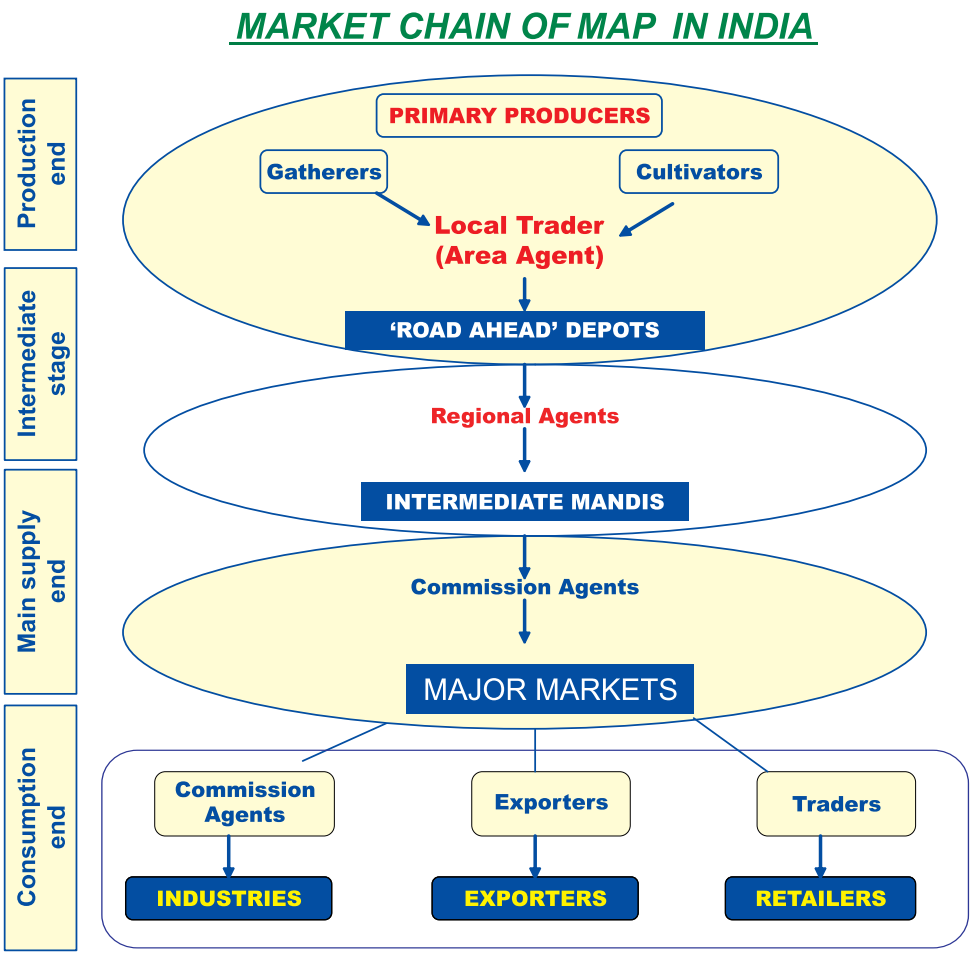

Fig. 1. *Market Chain of MAP in India*

Based on traded turnover in a year, the markets can be further classified as:

- Road head mandies (markets): 100 tons per year.
- Intermediate mandies (markets): 100 - 5,000 tons
- Regional mandies (markets): 5,000 - 50,000 tons
- Large mandies (markets): >50,000 tons

Based on type of transactions, mandies (markets) are categorized into two types:

- Traditional herbal markets: where the primary producers (gatherers or cultivators) sale their produce. Entire trade is handled by the commission agents or traders.
- Organized agricultural markets: where the primary producers bring the produce in the market yard and produce is sold by an open auction in presence of them.

Indian Acts Influencing MAP Sector

The following Acts influence the MAP sector in India:

i. The Indian Forest Act, 1927 and its subsequent amendments, 1930

ii. The Drugs and Cosmetics Act, 1940 and its amendments time to time

iii. The Seed Act, 1966

iv. The Wild Life Protection Act (1972)

v. The Foreign Trade Development and Regulation Act of 1992

vi. The Protection of Plant Varieties and Farmers' Rights Act, 2001

vii. The Biological Diversity Act, 2002

Constraints and Opportunities

For cultivation

Constraints

- MAP farming is a comparatively new occupation for farmers and the risk of failure is particularly high. In addition to the risk of crop failure, the farmers face serious market-related risks and difficulties in getting right price. Industry has the upper hand in deciding the price.
- In most cases, they do not have a guaranteed market and price premiums for cultivated material. Open price is decided by the traders on the basis of collected material from the forest ignoring that cultivated material will have input cost.
- Farmers do not get reliable market information about demand and pricing, which puts them in a vulnerable position when they go for sale. Local traders often transfer the price risks to them.
- GACP certification although introduced but, premium price for such certified material is not offered by the traders forthright.

- Institutional infrastructure that can provide technical support and remove marketing bottlenecks are missing in many states.
- Medicinal plants require specific soil and climate for expression of their best quality. However, there is no policy to regulate the cultivation of right species in right location which is standing in the way of assuring quality of raw drug even it is cultivated.
- Long gestation period and high risk are serious constraints. Many medicinal plants can be harvested only after three years or more. This is particularly true of the plants grown in high-altitude areas. As most farmers are poor, have small landholdings and lack credit, they cannot wait so long for returns. Understandably, they are reluctant to convert a significant part of their land to production of medicinal plants.
- Candidate species for cultivation are so large, and therefore, there is a clear need to develop technologies related to cultivation, harvesting, storage, transportation and quality control for many more species that are not available.

Opportunities

- Public–private collaboration can play an important role in removing many of the bottlenecks described above. Successful model of tripartite partnerships among the farmers' group of Gheshe village of Uttarkhand, HAPPRC and Dhawan International, a Delhi-based firm for cultivation of *Picrorhiza kurrooa* (kutki) and *Saussurea lappa* (kuth) could be replicated.
- Interest for Ayurveda herbs are increasing in Europe and America. A Dutch company IHC/VanderStelt imports Ayurvedic herbs from India and distributes them in the Netherlands and Germany as health products (capsules and tablets) to pharmacies, chemists, health shops and therapists. Currently, the total product range contains 55 products, all of them based on the Ayurveda principle. Many more similar companies may join in future.

For traditional medicine

Mode of action of various MAP in treating the diseases is yet to be explained fully in a language that modern medicine understands. Moreover, how different MAP material work for curing the same disease is often questioned. It is likely that two different molecules have the similar bioactivity as has been demonstrated by Central Drug Research Institute (CDRI) in case of *Bacopa monnieri* and *Centella asiatica*. Both are used as brain and nerve tonic but have two different bioactive molecules, bacosides and asiaticocides. There are now great opportunities to study ISM codified formulations in depth to explain the preventative and therapeutic mechanisms of herbal medicines. World should be explained with scientific data that how scientific, effective and time tested system these are and world can take benefit of such ancient wisdom.

For modern medicine

These are basic differences in modern western medicine and Ayurveda. Ayurveda emphasizes influence of environment, diet and emotion on health, while western medicine focuses on

only the problematic point for quick fix. Ayurveda goes to the root of disease, while western medicine only treats the symptoms mainly. Modern medicine was looking at traditional systems of medicine from the fence without having mind set to accept it. Of late, when many fourth generation diseases such as immune disorders, HIV/AIDS, etc., could not find cure in modern medicine, there are claims and records for successful treatment of such disorders by the traditional healers. Doctors are gradually accepting it as complementary medicine. Thus, there is an opportunity now for the ISM to share the knowledge of ancient wisdom with modern doctors through the research with modern gazettes and protocol and finally convince the world that it is neither complementary nor alternative or non-conventional medicines but it is fool proof mainstream medicine of Indian sub-continent.

Approaches for Meeting Emerging Challenges

The public–private collaboration supporting the cultivation of MAP is in its infancy. What can be done to promote large number of collaborations will depend upon a number of conditions that have to be met before the private sector get attracted to join program to support the cultivation of medicinal plants. These include:

- Building of infrastructures necessary for technical and marketing support
- Increased involvement of civil society in organizing farmers' groups and their capacity building to deal with public institutions and private companies as well collecting market information and building entrepreneurship
- Building social capital for improving efficiency of the chain and strengthening of medicinal-plant chain both vertically (e.g. producer–industry), as well as horizontally (e.g. strengthen the producer organizations) is essential in order to increase people's trust and ability to cooperate, and expand access to markets by networking of actors involved in the chain. In this process, mere consulting of stakeholders is not adequate. A more thoughtful collective investigation into the motives and underlying values of the stakeholders is essential in enabling sustained common action.
- Creation of greater demand for cultivated material is extremely important. Presently, the private sector has no sufficient reason to be involved in joint programms for cultivation as their demand is largely satisfied with the supply of legally or illegally procured raw drug material. Only large exporters are becoming interested in offering cultivation contracts to farmers for those species which are in short supply. Cultivated produce would be of interest to exporters as it would fulfill the traceability in comparison to collected material because of lack of transparency and documentation in the chain.
- The private sector will be more willing to support cultivation of medicinal plants if the cost advantage of collected material is removed. This can happen if the restrictions on collection from the wild are strictly enforced.
- The cultivation of MAP would provide strong impetus to agricultural diversification, leading to increased income and livelihood support to farmers.

Future Thrusts

Increased awareness about end-users' safety and safe usage are important, as well as more

collaboration and communication among providers of traditional medicines and practitioners. Safety of herbal medicines is to be addressed right from the safety and quality of raw drugs. Raw drugs are mainly procured either from cultivation or from the forest collections. Good cultivation and collection practices (GACP) define various steps of cultivation and collection to assure the quality and safety of the produce. However, the main challenge remains as to how to our reach to millions of MAP farmers and collectors with this knowledge, instead of thousands. The following activities may be useful for reaching the masses:

- Using every opportunity (meetings, workshops, and trainings) to bring representatives from multiple sectors (government, civil society, environmental, and private sector) and multiple levels (national, regional, and local) into the same room for action planning. Diversity is the mother of innovation.
- Providing support for negotiating new agreements.
- Producing and free distributing videos of various knowledge led activities.
- Encouraging media participation and collaboration activities in the MAP program considering media as partners.
- Developing a MAP website with links to all MAP stakeholders' websites.

In addition to these, to multiply the value of MAP by higher quality and new markets, common-ground goals of MAP sector stakeholders should be: i) establish certification (GACP and organic) and labeling; ii) provide training and information, iii) continuing research of all fields of MAP; iv) promote commercialization and investment; v) foster preservation of natural resources; vi) help to shape government policies; vii) institute insurance and risk management strategies and viii) conduct monitoring and evaluation.

Since farming is becoming more and more competitive, to maintain income levels, farm families across the country need to become more creative, diversified, and competitive. India would need a virtual transformation of the country's agriculture and rural economy–shifting towards higher value-added production by adding high value medicinal and aromatic crops and the creation of new businesses and job opportunities.

Conclusion

Upstream activities on development of herbal food and beverages, new formulations from traditional knowledge, phytochemicals, neutraceuticals, bioprospecting, new molecule search for pharmaceuticals, herbal base cosmetics, toiletries and fragrance, herbal health enhancing and dietary supplement products and downstream activities such as health retreats, health service, incubation center, herbal standard institute, herbal gardens, college and HRD, improved packaging, aroma therapy, herbal research center and human resource training are to be coordinated in synthesizing a new symphony for the benefit of poor and rich to achieve Indian ancient dream, "health for all". Cultivation will add flavour to such efforts by providing quality in all these activities since raw herbal material is the dominant and guiding input for all these products. Any single organization can not achieve the goal, if other stakeholders fail to imbibe enthusiasm.

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Country Status Report on Medicinal and Aromatic Plants in Nepal

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Introduction

Nepal is located in the main Himalayan range, and characterized by the presence of six floristic regions (Central Asiatic, Sino-Japanese, Southeast Asia-Malaysian, Indian, Irano-Turranean) with 8 ecological zones from tropical to alpine. The variation in elevation (60 m asl in tarai plain to the top of the world, 8,848 m asl) with diverse climatic conditions has favoured the occurrence of variety of plant species and making Nepal ecologically the most diverse country in the world. Major diversity rich areas include Tarai, Siwalik, mid hill, valley, high hill and mountains. It harbours rich flora and fauna, containing 35 types of forests, 75 vegetation units and 118 ecosystems. Nepal comprises only 0.09 per cent of the global land area but it possesses 2.7 per cent of the world's flowering plants which are conserved in 10 National Parks, 3 Wildlife and 1 Hunting Reserve, 6 Conservation Areas and 12 Buffer Zones, 1 national and 10 district level Botanical Gardens across the country (DPR, 2012). The genetic resources include 5,856 species of flowering plants, 28 gymnosperms, 853 bryophytes and 534 pteridophytes. The endemic plants comprise 284 flowering and 255 non-flowering species, 12 algae, 157 fungi, 48 lichens, 30 bryophytes and 8 pteridophytes. The medicinal and aromatic plants (MAP) database encompasses over 1,624 species (Shrestha *et al.*, 2001), constitute about 10 per cent of vascular plants. Those are distributed in 16 important plant areas (IPA) complexes for medicinal plants in 54 sites from Karnali to Kanchenjangha of Nepal (Anonymous, 2006). Sixty MAP have been categorized under threatened group by IUCN and CAMP.

The medicinal and aromatic plants, commonly called "*Jadibuti*" in Nepal (in India also) is one of the potential natural resources of Nepal. *Jadibuti* is regarded as an important development sector like other major resources: water, land, forest, MAP, human power, animal (*Jal, Jamin, Jangal, Jadibuti, Janashakti, Janabar*, respectively as 6 "Ja" in Nepali). Medicinal plants of the Himalaya are major source of income, employment and healthcare for millions of inhabitants in the region. Every year 10,000 - 15,000 tons of around 200 MAP plus non-timber forest products are harvested from the natural habitat. According to Subedi (2006), 161 species are commercially traded. Among them, 71 per cent are found in mid hills and 17 per cent in the high hills and mountain. About 310 species are endemics (higher number is enumerated in Mustang, Dolpa, Rasuwa, Sankhuwasabha districts).

MAP have significant contribution to the livelihood of rural communities; contribute above 3 per cent to the Nepal's GDP. They have high medicinal and immense cultural values. MAP supply raw materials for industries, help in biodiversity conservation, soil conservation and environment protection. These species been supporting to achieve the country's goal of poverty reduction.

Species having high demand and value in the international market are overexploited and have become vulnerable in Nepal. Some threatened species are disappearing in the natural habitat. Therefore, 20 important species have been banned for collection, transportation, trade, and export without processing and certification. As a result, collection and supply of high value MAP niche products is declining from the country. This situation has direct impact on the livelihoods of millions of rural communities. Shortage of raw materials has greater effect on suppliers, processors, and producers of Ayurvedic medicines, and cosmetic products. Sustaining the natural resource base is a must, but is a great challenge for Nepal, especially in the highland areas where alternate livelihood opportunities for the communities is less due to poor agricultural situation.

Area, Production and Productivity

Most MAP are not cultivated but harvested/ collected from the forests. Therefore, the exact area under medicinal plants other than commercially grown essential oils in Nepal is unknown. The area is not estimated as it needs huge resource to measure the land under each species because almost all medicinal plants grow in the forests and community lands having varied configurations. Distribution and diversity of a species varies from location to location. Few areas have been roughly estimated through resource mapping for particular species. Due attention is not paid to estimate area of the medicinal plants. The cultivated area of chiretta (*Swertia chirayita*) is being expanded in the hill districts where its area may reach to 200 ha. The area is roughly estimated based on the quantity of harvest. If the collection and export of chiretta for a year is 300 tons, the total average area would be 300 ha as one hectare of forest can produce average 1,000 kg (Barakoti, 2004). But, there is no access of the collectors in all growing areas and the crop is not harvested. The produce of cultivated area is also added in the total export quantity. This applies to other MAP also. The area production and productivity of aromatic plants commercially cultivated in terai region are presented in Table 1.

The production of MAP is the total quantity collected as wild and exported+purchased/ used quantity by the herbal companies. In addition, local healers also use to prepare home medicines. The tentative production data is the quantity collected by all 75 District Forest Offices (DFOs) that allocate licenses for collection and export of MAP for semi-processing and or direct export. The MAP data of the DFOs are compiled by the Department of Forest. This will be the production data for each MAP of the country. In some cases, there is illegal export from the borders that can not be added in the total production. The collection and production of a MAP vary from district to district and year to year. The total production of MAP for the year 2011-12 is 2,550 tons which is highly reduced as compared to the past years. It is nearly equal to the production during 2001-02 (2,484 tons).

The data of each collected/ harvested MAP is available as quantified production. However, the actual productivity of most MAP is not yet estimated. The main reason is the unknown area

Table 1. Area, production and productivity of aromatic (essential oil) species (2012)

Aromatic plant species	Cultivated area (ha)		Production (tons)		Productivity (kg/ha)		Selling price, NRs/kg
	HPPCL	Others	HPPCL	Others	HPPCL	Others	
Mentha	142.0	300.0	7.20	4.8	50.70	16.0	1,800.0
Chemomile	160.0	100.0	0.42	0.3	2.65	3.0	23,000.0
Citronella	106.0	10.0	5.60	1.0	52.80	100.0	1,500.0
Lemon grass	76.0	20.0	3.00	1.2	39.50	60.0	1,750.0
Palmarosa	33.0	5.0	1.65	0.35	50.00	70.0	3,500.0
French basil	16.0	-	0.21/ Akarkada 4/2.0		13.10/ 500	500.0	4,000.0
Total	**533.0**	**435.0**	**17.87**	**9.65**			

of the produce in the hills. Estimation of productivity of particular MAP can be found from different geographical zones or localities. The productivity of major aromatic plants is given in Table 1. Rough productivity of chiretta in the forest is estimated based on the quantity harvested from one *Ropani* (equiv. to 500 m^2) which is approx. 800-1,200 kg/ ha.

Major Uses

Medicinal and aromatic plants (MAP) in Nepal are mostly traded and exported (>90%). They are also used for local healthcare in two ways: direct use in crude form to cure human diseases, disorders and through traditional knowledge (TK). In this case, primary processing/ post-harvest practices are done as per TK following some Ayurvedic and local healers' methods. Most MAP species possess medicinal values in the whole plant. Others have in bark, root, leaf, fruit, flower, sap, rhizome, bulb, or aerial parts based on species. Many preparations are used by professional healers (*Baidyas*) *Gurau* in Tarai Tharu community, *Dhami-Jhankri* in Hills and *Amchi* in high hills and mountains. About 2-4 per cent of the total production is consumed by the people in this way. MAP are also used in healthcare of domestic animals. Another portion (4-6%) of MAP products is used in the Ayurvedic medicines manufacturing companies. About 80 per cent people, particularly living in the rural areas, depend directly or indirectly on the traditional medicine based on herbal drugs. Most species are used since time immemorial under different traditional (folklore) systems including Ayurvedic, Homeopathic and Tibetan. Only 15-20 per cent species are used as modern medicine.

MAP have been utilized in both traditional and modern medicines. In the traditional system, several medicinal plants and their parts are used singly or in combination by mixing with others. These are prescribed in different forms: paste, decoction, juice, powder, infusion, syrup, etc. The products are commonly used to cure cold, cough, bronchitis, diarrhea, dysentery, and other problems. In the modern medicine, many synthetic chemicals are used. Plants are the only source for life saving and essential medicine. They act as a source of materials for synthesizing valuable drugs. Similarly, essential oils produced from aromatic plants and spices are used in Nepalese cookery, medicines, flavoring, cosmetics and toiletries. The Ministry of Health, GoN

had listed 339 essential Ayurvedic drugs under 44 main headings of symptomatic diseases (Malla and Shakya (1984-85). Herbal drug industry in Nepal has met about 25 per cent of the drugs requirement and the rest is fulfilled through the imports.

About two dozens of old and new public and private Ayurvedic companies have been established in different parts of the country. Examples are: Singhdurbar Baidyakhana Samiti, Nepal Aushadhi Limited, Herbs Production and Processing Company Ltd. (HPPCL) as government shared companies. Among the private companies, Piush Varshiya Aushadhalaya, Sri Krishna Aushadhalaya and Arogya Bhawan are old and reputed. Joint ventured companies are Gorkha Ayurved Company (France), Cosmos (Japan), Neelam Herbs (China). These and other companies use MAP to produce varieties of Ayurvedic drugs, cosmetics, toiletries etc. as per market demand. There are more than 400 preparations of these manufacturing companies which consume around 4-6 per cent of the national production. There are some processing factories located in central and western tarai plain of the country. They process/ distill essential oil producing species, like spikenard, valerian, juniper, mentha, chamomile, French basil, citronella, palmarosa, lemon grass, etc. Almost all of the essential oil producing plants are processed in Nepal, and the extracted/ distilled oils are exported abroad. Major portion of MAP is sold/ exported in crude form and only less than 10 per cent is consumed in the country.

Significant Achievements

Germplasm collection, characterization, conservation and documentation

The genetic resource of medicinal and aromatic plants in Nepal Himalaya is rich. MAP species were popular since the Vedic era of *Rishi-Munis* who researched the Himalayan flora including the life saving herb *Sanjeevani Buti*. According to the *Ramayan*, a Himalayan region was endowed rich in with high value MAP since *Rishi's* Vedic era.

MAP documentation started since the period of Mandev Era 301, when the oldest book called *Saushrut Nighantu* was written on palm leaves in *Devnagari* script and *Sanskrit* verses where 278 MAP were recorded (Malla and Shakya, 1984-85). Ayurveda continued, and in 19th century, the Rana PM Bir Shamsher liked to familiarize the names of useful medicinal plants of Nepal to help update and improve the traditional medicine system. Kabiraj Ghananath Devkota prepared herbal pharmacopoeia and named "Bir Nighantu". Rana PM Chandra Shamsher renamed it as "Chandra Nighantu". But the detailed work of Mr Devkota was considered as herbal Encyclopedia consisting of 11 volumes, 8 volumes being botanical.

Efforts have been made to collect, evaluate, characterize and document the available MAP species from Nepal. Malla and Shakya (1984-85) reported 690 species, the Department of Plant Resources (then Department of Medicinal Plants) documented 701 species, Shrestha *et al.* (2001)-1,624 species, and later (CBS, 2011) data suggest that 2,300 MAP were identified in Nepal. Ever-increasing taxa in Nepal encourage scientists and reveal that the country may further enrich with MAP. According to MAPDON (Shrestha *et al.*, 2001), angiosperms group comprises the highest number of 173 families, 868 genera and 1,515 species. MAP fall under gymnosperms, ferns, lichens, fungi, liverworts, and moss (Table 2) belonging to herb, tree and shrub groups. The germplasm collected by scientists/taxonomists are being preserved in the National Herbarium Godavari, Kathmandu.

The database shows significant achievements in identifying genetic diversity, most species and populations are adapted and conserved. Distribution of priority species has been observed in different physiographic regions. General trend shows that species and genetic diversity vary along with altitude. In Nepal, diversity of tree species decreases and herb species increases with altitude.

Table 2. MAP genetic resources in Nepal

Plant groups	Families	Genera	Species
Fungi	9	9	9
Lichens	4	8	18
Liverworts/mosses	4	5	6
Ferns and allies	20	36	58
Gymnosperms	8	12	18
Angiosperms	173	868	1515
Monocot	23	132	197
Dicot	150	736	1318
Total	**391**	**1806**	**3139**

Source: Shrestha et al., (2001).

Characterization and evaluation of the above germplasm have been done in limited areas. Thorough survey/expedition of forests and rangelands may identify additional MAP resources. However, there is need to verify and characterize employing different methods including molecular techniques. Characterization is needed for better identification and confirmation of the species.

Conservation of MAP *in situ* has become a challenge for Nepal. The word conservation has been popular in media and published materials from time to time. But, Himalayan medicinal plant diversity is waiting for effective conservation plan/ program in the days to come. There is positive impact of community forestry user groups in conserving MAP in most areas. However, the most demanded and high value MAP in the high hills such as Gentian, Spikenard, Valerian are not conserved but threatened. Their population is declining *in situ* due to overharvesting, theft and other reasons. There are 60 high value species already in various degree of threat as categorized by IUCN and CAMP. Severe genetic erosion and vulnerability of the priority species has occurred. Advocacy advertisements and publications only could not mitigate the situation. Hence, 30 MAP species have been prioritized for research and agro-technology development (DPR, 2012).

Population and diversity of 20 MAP species, particularly the high value ones, have been highly declining in their natural habitats leading to threatened, extinct categories. Despite education on conservation and awareness on sustainable harvesting, the trend was found to be continued. Hence, the Government of Nepal formulated special regulation to control it and preserve/ protect the following 20 species in the natural condition (Table 3).

Table 3. MAP species banned in Nepal

S. No.	Local name (Nepalese)	Scientific name
I. Banned for collection, transportation and trade		
1	Panchaunle	*Dactyloriza hatagirea (*D(D.Don) Soo
2	Walnut	*Juglans regia* Linn.
3	Jhyau	Lichens
II. Banned for export outside the country without processing (Not applicable for cultivated products)		
1	Talispatra	*Abies spectabilis* (D.Don) Mirb.
2	Sugandhakokila	*Cinnamomum glaucescens* (Nees) Hand.-Mazz.
3	Jhyau	Lichens
4	Jatamansi	*Nardostachys grandiflora* DC.
5	Sarpagandha	*Rauvolfia serpentina* (L.) Benth.ex Kurz
6	Lauth Salla	*Taxus wallichiana* Zucc.
7	Sugandhawal	*Valeriana jatamansi* Jones
8	Shilajeet	Rock exudates
9	Yarsagumbu	*Ophiocordyceps sinensis* (Berk.) Sacc
III. Banned for felling, transportation and export		
1	Satisal	*Dalbergia latifolia* Roxb.
2	Okhar	*Juglans regia* Linn.
3	Bijayasal	*Pterocarpus marsupium* Roxb.
4	Sal	*Shorea robusta* DGaertn.
5	Khayar	*Acacia catechu* (L.F.) Willd.
6	Champ	*Michelia champaca* Linn.
7	Simal	*Bombax ceiba* Linn.
IV. Banned for export without identification and certification		
1	Kutki	*Neopicrorhizia scrophulariiflora* (Pennell) D.Y.Hong

Source: Plants of Nepal: Fact Sheet, GoN, MoFSC, Dept. Plant Resources, Kathmandu, 2012.

Threatened medicinal and aromatic plants

There are 60 species of MAP listed as threatened with various degrees by CAMP and IUCN and are given in Box 1.

Variety development

The variety development work has practically not been undertaken for even the most valuable medicinal plant species contrary to agro-crops. Local landraces are being grown, promoted

Box 1. Threatened MAP species in Nepal

Threatened MAPs in Nepal include : Acacia catechu (T), *Aconitum balangrense* (EN), *Aconitum bisma* (DD), *Aconitum ferox* (DD), *Aconitum gammiei* (T), *Aconitum heterophyllum* (V,T), *Aconitum laciniatum* (T), *Aconitum spicatum* (V,T), *Allium hypsistum* (V), *Alstonia neriifolia* (EN,R), *Alstonia scholaris* (V,R), *Arisaema costatum* (LC), *Arnebia benthamii* (V), *Asparagus racemosus* (V), *Bergenia ciliate* (T), *Butea monosposperma* (V,EN), *Corydalis megacalyx* (EN), *Crateva unilocularis* (EN,R), *Curculigo orchioides* (V), *Dactylorhiza hatagirea* (EN), *Dalbergia latifolia* (V), *Delphinium himalayai* (V), *Dioscorea deltoidea* (EN,T), *Elaeocarpus sphaericus* (V), *Ephedra intermedia* (EN), *Ephemerantha macraei* (V), *Fritillaria cirrhosa* (V), *Gloriosa superb* (EN), *Heracleum lallii* (EN), *Jurinea dolomiaea* (NT), *Lilium nepalense* (DD), *Maharanga bicolor* (DD), *Maharanga emodi* (DD,K), *Meconopsis dhwojii* (NT), *Michelia champaca* (CR,EN), *Nardostachys grandiflora* (V,V), *Neopicrorhiza scrophulariiflora* (V), *Operculina turpethum* (EN), *Oroxylum indicum* (EN), *Otochilus porrectus* (EN), *Paeonia emodi* (V), *Panax pseudo-ginseng* (V), *Paris polyphylla* (V,V), *Piper longum* (V), *Pistacia chinensis* (R), *Podophyllum hexandrum* (V), *Pongamia pinnata* (DD,K), *Pterocarpus marsupium* (CR), *Rauvolfia serpentina* (CR,EN), *Rheum austral* (V), *Rheum moorcroftianum* (NT), *Rheum nobile* (V,R), *Rubia manjith* (V), *Swertia angustifolia* (EN), *Swertia chirayita* (V), *Swertia multicaulis* (DD), *Taxus wallichiana* (EN), *Tinospora sinensis* (V), *Valiriana jatamansi* (V).

Legend: CR: Critically endangered; DD: Data deficient; EN: Endangered; K: Insufficiently known; LC: Little cared; NT: Nearly threatened; R: Rare; T: Threatened; V: Vulnerable

and expanded in a few areas only known as herbal farms. Development of a MAP variety will be a new work for Nepal. No research is planned for identification and development of variety MAP so far. In case of exotic essential oil species, evaluation of imported varieties species has been started. For example, new German variety of chemomile was evaluated in Kathmandu valley for the first time in 2011. This variety, preferred in Germany, has performed better under valley conditions (1,300 m asl) in Nepal.

Cultivation practices

There is ample scope of MAP cultivation in the cropping and arable lands and in community forests. Research and development works in propagation, cultivation of MAP are limited. But, there is increased awareness among farmers, cooperatives, government agencies and NGOs in cultivating MAP and increase production and income. Emphasis is given to commercial cultivation of MAP for additional income and employment generation of subsistence farmers, *in situ* conservation of the threatened MAP, and utilization of the unproductive land, etc.

Despite the advocacy for cultivation and conservation since 3 decades, cultivation of indigenous/ endemic MAP has been taking place since one and half decade only. Cultivation technologies and management practices are demanded by the clients for domestication of high value MAP (Barakoti and Pant, 2008) including wider range of extension agents across the country. Thirty species of MAP of high importance are recommended for cultivation. But, appropriate technical know how is lacking and cultivation research and extension part is to be mandated to NARC and DoA experts under MoAD and share responsibility among the Govt. partners.

Cultivation of essential oil species is predominant in *Tarai* region. Commercial cultivation was started by the government owned Herbs Production and Processing Company Limited

(HPPCL) since 1980. HPPCL has its production farms and processing units for six essential oil species. Later, private entrepreneurs including Dabur Nepal were involved in production of different herbs in on-farm condition. Dabur has been producing and distributing seedlings/ saplings of more than a dozen of MAP in Nepal. Other companies involved in cultivation and promotion are Natural Product, Chaudhari Biosis, Shambhala Herbal, and cooperatives. Some government agencies (DPR, NARC, NAST, other), I/NGOs, and private companies have been involved in R&D activities. As a result, cultivated area, and production have been increased to some extent. Palm Agrotech and Bio-Energy Nepal (P) Ltd. has initiated commercial cultivation of stevia and aloe vera on contract basis with farmers in 40 districts since 2010. Cultivation package of practices is available for about one dozen of species only.

Commercial production of different aromatic oil species (mentha, *Citronella*, lemon grass, palmarosa, chamomile, French basil) by HPPCL on its farms and private companies is encouraging. Cinnamon, *Zanthoxylum*, lemon grass, etc. are mainly grown in the community forests. However, the production and export of indigenous medicinal plants product could not be increased, but these rather decreased.

Commercially cultivated and processed aromatic plants

The commercially cultivated and processed aromatic plants/products are as follows:

1. *Cymbopogan flexuosus* (lemon grass oil), 2. *Cymbopogan martinii* stapf. var. motia (palmarosa oil), 3. *Cymbopogan winterianus* J. (*Citronella* oil), 4. *Matricaria chamomilla* L. (chamomile oil), 5. *Mentha arvensis* L. (mentha oil), 6. *Ocimum basilicum* L. (French basil oil), 7. *Tagetes glandulifera* (Mill.) (blake tagetes oil), 8. *Vetiveria Zizanioides* (Linn.) (nash vetiver oil), 9. *Zingiber officinale* Rose (ginger oil).

The multinational company, Dabur Nepal, has also prioritized MAP species for commercial cultivation mainly for use in its factory located in Nepal and India. The R&D works had been carried out through cultivation of following MAP in different parts in the country.

***High altitude* (*Jumla, Marpha, Gunchha, Khawa*):** *Taxus baccata* (loth salla), *Anacyclus pyrethrum* (akarkara), *Saussurea lappa* (kuth), *Picrorrihiza scrofularifolia* (kutki), *Swertia chirayita* (chiraito), *Rheum australe* (padamchal), *Valeriana wallichii* (sugandhawal), *Zanthoxylum armatum* (timur).

***Mid altitude* (*Kakani, Kavre*):** *Asparagus racemosus* (satawari/kurilo), *Valeriana wallichii* (sugandhawal), *Swertia chirayita* (chiraito), *Zanthoxylum armatum* (timur), *Anacyclus pyrethrum* (akarkara), *Rubia manjith* (majitho).

***Low altitude* (*Bara, Parsa*):** *Withania somnifera* (ashwagandha), *Piper longum* (pipla), *Asparagus racemosus* (satawari/kurilo), *Anacyclus pyrethrum* (akarkara), *Rauvolfia serpentina* (sarpagandha), *Desmodium gangeticum* (salperni), *Uraria pitta* (prishnaparni) (kachur).

Disease and pest management

This area is still in infancy. Diseases and insect pest surveys and surveillances have not been conducted even for the commercially cultivated species. However, little information is available on this aspect. Some diseases and insect pests of particular species are known but their

management practices have not been developed. Very few studies had been carried out but were not conclusive. There are about 12 commercially cultivated MAP species but recommended practices for the management of diseases and insect pests are practically not adopted in the field, except weeding.

Production of quality seed and planting material

Quality seed and planting material are mostly based on natural resource. Essential oil species which have been commercially cultivated since three decades have more or less organized system of seed production and raising planting material in the nursery. The government owned Herbs Production and Processing Company Limited has been practicing it along with other later established public and private companies. Dabur Nepal has established a sophisticated nursery in Banepa valley (near Kathmandu) to produce and sell seedlings/ saplings of medicinal and aromatic plants for cultivation in the high, mid and low hills and *tarai* region. It has been exporting quality seedlings from Nepal to different countries parts including India.

Primary processing, value addition and product development

These practices are gradually being adopted for a few MAP. Primary processing is done locally in the field and at collectors' home. The process undergoes a number of operations after harvesting: washing/ cleaning, drying, sorting/ grading, bundle making and storing of all plant products. Almost all medicinal plants are sold and exported in this form. Cleaning is done for the rhizome/ roots of spikenard, valerian, atis, gentian, etc. whereas drying, curing, are done to chiretta (Barakoti, 2009) and other plants. The essential oil producing species are allowed for 2-3 days for drying/ weathering in the field. Spikenard, valerian and other essential oil species are further processed in a boiler plant by the distillation of rhizomes/roots. The farmers are not well trained to perform all practices safely maintaining quality.

Care should be taken while harvesting, e.g. uprooting chiretta plants (Barakoti, 2009; Barakoti, 2004) as some weeds and unwanted parts may come out together. Weeds and other species may degrade quality if they are not removed before drying and curing. Diseased, immature, mechanically damaged, broken seeds, must be sorted out to make the product uniform, better quality and hygienic.

The cleaned and dried products are finally sorted out and graded as per size and quality. Simple packing is done to store and also to transport and deliver to local market or processing/ manufacturing factories. Local materials mainly made of bamboo are traditionally used to pack and bind the product. Jute bags and plastic bags are also used. Care should be taken to make the product healthy and good quality. The situation reveals that there is lack of improved stores, collection and grading/ packaging centers and good packing materials.

Local value addition is limited due to lack of appropriate technologies and support structures. For exporting MAP products, there will be a need to take into account the WTO trade regulations and certification process. Value addition and product development of MAP are done either in the government owned (HPPCL, Singdurbar Baidyakhana Samiti) or in the private companies (Gorkha Ayurved Company, Cosmos and others). They have been producing diverse products from different MAP used and sold as medicine, tonic, and cosmetics.

Marketing, commercialization and trade

Marketing of the MAP is done mainly through the Indian trade hubs to Asian, European, American and African countries as raw materials for pharmaceutical, fragrance and flavour industries. Main buyers are India, China, USA, Japan, Korea, Pakistan, Sri Lanka, Bangladesh, Malaysia, Singapore, Germany, France, Italy, UK, Spain, and others. There is high demand of quality MAP worldwide and no market problem for the quality branded products. Major portion (around 80%) is exported to India. Around 5-10 per cent is used for local healthcare and in domestic Ayurvedic drugs manufacturing companies. The traders and middlemen have been benefited from the business of medicinal plants rather than rural collectors. About 80 per cent local healthcare is done through the MAP mainly in rural hills areas.

There is increased demand of the selected MAP products in the market. However, due to inadequate availability against demand and inferior quality, sometimes less demand is made by the traders and exporters. Market demand is fluctuating mainly based on price. The product demand, as an example, is given in following order of priority: Yarshagumbu>Spikenard>Valerian>Chiretta>Atis>... A market demand of 10 MAP species assessed by India is presented in Table 4.

Table 4. Demand of key medicinal plants by India in 2004-05

Local name	Scientific name	Demand (tons)
Chutro	*Berberis aristata*	1830
Chiraito	*Swertia chirayita*	1285
Somlata	*Ephedra gerardiana*	920
Jatamansi	*Nardostachys grandiflora*	866
Sarpagandha	*Rauvolfia serpentina*	588
Atis	*Delphinium himalayai*	410
Kutki	*Neopicrorhiza scrophularifolia*	317
Sugandhawal	Valeriana jatamansi	216
Kakarsinghi	*Pistacia chinensis*	120
Tejpat	*Cinnamomum tamala*	88

Source: Centre for Res. and Planning and Action (CERPA), 2004, India

Despite the high demand of MAP products, some marketing problems are faced by producers, collectors, traders and processors. High fluctuation in price is a problem and often observed for some MAP products. For example, chamomile oil sold at NRs.35,000 per litre in 2010, was sold at less than NRs 25,000 per litre in 2013. It compelled to keep stock of processed oils by individuals and companies (eg. HPPCL). Price fluctuation has often resulted in collection, and production of the product. Lack of market access/ information/ network/ management for the local collectors/ producers was observed. Market is controlled by a few traders in the district and in region. It is heard that price is monopolistically fixed by Indian traders. They used to pay money in advance to the collectors before harvesting. Seasonality of MAPs availability mainly during summer to autumn is also a problem for collection, storage and trading.

Constraints and Opportunities

Constraints

A number of constraints/ problems for the development of MAP species and herbal products have been identified in production, processing, marketing, and infrastructure. There is lack of facilities in transportation, irrigation, electricity, collection center/ stores, processing, laboratory etc. Technical and technological problems have been identified in quality planting materials, high yielding varieties, characterization of germplasm, organic production and certification, soil fertility management, plant protection, processing techniques, etc. Research component has not received priority in MAP development projects. Therefore, technical problems occurred during project implementation could not be resolved without technology in hand. Research as engine should identify practical solutions of the problems/ constraints.

Problems in conservation include deforestation and degradation due to forest fire, open grazing. There is competition in collection/ premature/ unscientific/ harvesting of several MAP species. Lack of sustainable harvesting techniques for regeneration and cultivation practices for domestication and difficulty to propagate and produce planting materials of some species are the felt constraints.

Similarly, lack of suitable technology for production and processing, lack of quality products to compete market, and lack of investment for agri-business of MAP are the major constraints. The investment in research and development (<0.13 of the GNP) is negligible as compared to the SAARC countries. Managing quality seeds, planting materials, trained/ skilled manpower, knowledge of MAP in various aspects, organic pesticides seem challenging.

Opportunities

Good opportunity to develop traditional and modern medicines prevails in Nepal. The most relevant opportunities for MAP are suitable geographical environment: altitudes, climate and soil to grow various high value species. There is increasing interest/awareness of farming communities, cooperatives, government agencies, private sector, NGOs, service providers to promote MAP in developing business enterprise. Local network/ media for sharing information also improved and processing and value addition considered. The government policy is conducive in promoting MAP and there is high demand of quality product from abroad. The various sources revealed a number of biophysical and socioeconomic opportunities. Some of the identified opportunities could be listed as follows:

- Favourable agroclimatic conditions for domestication of MAP from wild forms
- Ample scope of cultivating MAP under agro-forestry systems
- Demand of raw materials of various MAP from India, China and other countries
- Some of the high value species are in domestication process in private lands
- Farmers leaders and local agencies are interested to promote MAP
- Awareness of locals on production, conservation and commercialization
- Local NGOs, groups and cooperatives formed to promote medicinal plants

- Market information is being accessible through media and local links
- Favorable government policy (MAP and NTFP Development Policy, 2004)

The government's policy intends to promote high value MAP for significant contribution in Nepalese economy by 2020. It encourages cultivation, *in situ* and *ex situ* conservation of important medicinal plants, aims to support primary processing for increasing employment and income locally, carry out collection, storing, processing, value addition through the involvement of private sector and local agencies. The policy also intends to make competitive for improving the livelihoods and poverty reduction through the use of MAP. It aims to provide support in infrastructure, technical knowledge/ capacity development and marketing management.

Approaches for Meeting Emerging Challenges

Despite the opportunities mentioned above, there are different opinions of researchers, producers, and stakeholders on the approaches to mitigate the increasing challenges of MAP in Nepal. Based on the existing situation, previous experience, feedback from key informants, an effective working approach and modality needs to be identified. A proposition of ACoS Nepal (2009) suggests to revise the existing working approach and modality for better employment, income, and health through promotion of MAP under the changed context of New Nepal Construction. Public-private partnership (PPP) approach taken by the government of Nepal is to be followed together with the third pillar of economic development, cooperatives. Instead of Public-private partnershio (PPP), Pro Poor Public Private Partnership (PPPPP) was suggested (Barakoti, 2009). Collaborative and partnership arrangements with farmers/ groups, I/NGOs, chambers of commerce and industries, lending agencies, traders and processors need to be established and strengthened.

It is believed that the grass-root level farmers and traders should have ownership and share in each enterprise. It is suggested that inputs and services should be made available to the groups (ACoS Nepal, 2009) and in partnership with concerned organizations. Fund should be provided to the grass-root farmers. Project implementation must be done through one window system. Formation of users' groups, action planning, review, monitoring and evaluation of ongoing activities by users and office personnel are required.

Enterprise should be created based on local resource, target group and market demand. In order to promote medicinal herbs, more investment should be done in farming/ cultivation to produce more quality products. Domestication and cultivation of MAP in private land and community forests should be encouraged. Infrastructure and technical capability should be developed for developing herbs based enterprise. According to local governance act, local agencies must invest 20 per cent revenue received from the herbs export, while ACoS Nepal (2009) suggested for 25 per cent. The following organizations are suggested to be selected as partner actors as per need:

- Village Development Committee level: Range Post/Agri. Service Centers, CBOs
- District level line agencies: DFO, DADO, DPRO, DSCO, ARS, DCCI, DDC
- Regional and central level : RARS, RDA, NARC, DOA, DPR, DFRS
- Potential I/NGOs working in the project districts and in the region

Future Thrusts

- Increased and sustained production of MAP, commercialization, industrialization, and increased export of processed and value added product.
- Exploring full potentiality of MAP product and generate higher employment and income from them
- *In situ* and *ex situ* conservation, domestication and commercial cultivation of high value MAP in different ecological zones
- To build technical and management capacities of scientists, technicians, producers, traders and processors in various aspects of MAP
- Formation of a central level authorized body, called MAP Promotion Board or Committee, for overall coordination, planning and management of public and private organizations, and cooperatives involved in MAP production, research, extension, processing, marketing promotion in Nepal
- Increase MAP GDP from 3 to 10 per cent within 10-15 years and declare Nepal as a country of Himalayan MAP with ancient Yoga and Ayurveda in 2020
- Recommend compulsory utilization of plant originated medicinal products in national health delivery system of the countries in Asia and the Pacific region.
- Of the total revenue collected from MAP, atleast 25 per cent should be invested in local development and promotion of MAP species
- Sharing knowledge and experiences among the Asian and other experts of MAP and form a coordinating body for making collaborative arrangements, planning and implementation of joint venture multi-location projects/ programs in the region.

Conclusion

Sustaining the natural resource base is a must, but is a great challenge for Nepal, especially in the highland areas where alternate opportunities of livelihood and income generation for the communities is less and agriculture production situation is poor. Planning and budgeting research and extension promotion strategies, and activities for economically important medicinal plants is a priority issue for developing suitable cultivation technologies aimed at domestication and commercial cultivation. The available technologies need to be updated, tested, verified and documented. Likewise, sustainable harvesting techniques should be identified and adopted by grass-root users for *in situ* conservation of MAP. Research and management are necessary for processing and improving quality of products and increasing organic production. MAP should be included in the income generation activities of the community forestry to enhance rural income supporting livelihoods and reduce poverty. Capacity of the MAP collectors and cultivators needs to build up in areas such as cultivation, sustainable harvesting, post-harvest/ primary processing through training, visits, interactions etc. GoN needs to support marketing and review the national and international markets and ensure promotion of MAP species. The MAP and NTFP Development Policy 2061 B.S. needs to be revised. National and international support and collaboration are also needed in various areas to improve and develop the existing situation of MAP in Nepal.

Integrated approach should be employed in implementing projects related to promotion of MAP species. There should be close links between research, extension and development partners/ stakeholders. Involvement of public and private sectors and cooperatives in the production and processing of MAP should be encouraged. Use of herbal drugs should be incorporated in the health delivery system of the government. Domestic and foreign markets need to be channelized. Species banned for collecting and use are to be reviewed for cultivation and utilization. The current royalty system needs to be revised in favor of commercialization and trade promotion. Certification and taxation systems should be reviewed and simplified. Multiple taxes should be avoided and unnecessary checking and illegal payment on the road heads must be controlled. Storing and laboratory testing facilities of MAP on India's borders should be established and managed, properly.

Domestication and cultivation research should be mandated to NARC under MoAD. Research and production should go hand in hand for sustainable utilization, commercialization and industrialization. The government policy should include investment plan in cultivation, marketing, processing and value addition. Raising nurseries and distribution of planting materials to the growers in subsidized rates is necessary. Peoples' participation and participatory approach should be encouraged. The infrastructure, collection centers, improved stores, processing plants, quality testing laboratory facilities need to be need to be developed.

It is hoped that collaborative approaches among the Ministry of Forest and Soil Conservation, Ministry of Agriculture Development, Nepal Agricultural Research Council and Nepal Academy of Science and Technology in research activities and with Agro-Enterprise Center, I/NGOs, would be developed for promotion of MAP. Appropriate extension activities need to be initiated in the Department of Agriculture. Human resource development should also be given priority attention. A central Govt. authorized Coordination Agency or Board is necessary for the overall management and development of MAP sector in Nepal.

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Country Status Report on Medicinal and Aromatic Plants in Pakistan

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Introduction

Pakistan is situated between latitude 23° and 37° North and longitude 61° and 76° East and has an area of 87.98 million hectares. The annual rainfall ranges from 50 mm in the South to 2,032 mm in the northern mountainous region. About 70 per cent of the rain occurs during the monsoon season (July-September). However, occasional showers also occur during the winter. The summer months, except in mountainous region, are very hot, while the winter months are mild in the plains and extremely cold in hilly regions. Temperatures fluctuate from below zero in the mountainous range to 52°C in the southern plains. Pakistan varies in altitude from mean sea level to 8,611 m (K2 being the second highest peak in the world) and therefore, has a variety of climatic zones and a unique biodiversity.

Pakistan has a wide range of agro-climatic zones owing to the variation in climate and topography where all kinds of crops, fruits, vegetables, and medicinal plants are grown. The agriculture sector maintains the livelihood of the large rural population and ensures that sufficient food is available for domestic needs. The majority of the farmers have small holdings producing for their own needs. They have a few resources which are vulnerable to many risks of natural hazards and socioeconomic dilemmas.

Due to wide variation in climate and temperature, Pakistan is endowed with rich resource base of indigenous medicinal and aromatic plants (MAP) spread over a wide range of ecological zones and form an important component of the natural wealth of Pakistan. These plants are traditionally used to cure a variety of diseases in human beings and also for imparting flavours in food and traditional dishes. It has been reported that there are about 4,950 plant species available in Pakistan and out of these, only 300 species (6.1%) are identified as medicinal plant species (FAO 2002). Shinwari, (2010) reported that about 6,000 plant species are known to occur in Pakistan of which 1,010 species (16.8%) have been identified for potential medicinal use. It has also been estimated that 70 per cent of the total species are confined to a particular region and about 30 per cent occur in two or more regions. The country has four

phyto-geographical regions (i) Irano-Turanian (45% of species), (ii) Sino-Himalayan (10% of species), (iii) Saharo-Sindian (9.5% of species), (iv) Indian element (6% of species). Despite the Saharo-Sindian region being the biggest region, the diversity of species available in this area is the lowest among all phyto-geographical regions (Ali and Qaiser, 1986).

Area, Production and Productivity

On the basis of production, the existing MAP resources could be classified into two groups, viz., naturally occurring and cultivated MAP. The naturally occurring MAP can be sub-divided as (a) wild plants (b) plants growing as weed in the forest population, rangelands or cultivated fields. MAP growing naturally at high hill forests and range land areas require a long growing period for growth to reach maturity for commercial exploitation. Whereas those occurring on foot-hills and plains appear annually as spring flora and a few of these are also perennials. Some important weeds, namely, *Fumaria indica*, *Carthemus oxycantha*, *Chenopodium album*, *Asphodelus tenuifolius*, *Silybum marianum*, *Cleome viscosa*, *Convolvulus arvensis*, and *Solanum nigrum* are such plants that can be collected, dried and sold in the market. These plants can also be classified into two broad categories (A & B) for the purpose of regeneration and propagation. Group A refers to high altitude plants that require a long growing period (2-8 years) to reach maturity, for example, *Aconitum heterophyllum*, *Acorus calamus*, *Asparagus racemosus*, *Atropa acuminata*, *Berberis lycium*, *Colchicum luteum*, *Dactylorhyza hatageirea*, *Digitalis purpurea*, *Dioscoria deltoidea*, *Ferula foetida*, *Gentiana kurroo*, *Paeonia emodi*, *Picrorhiza kurroo*, *Podophyllum emodi*, *Sussurea lappa*, *Saxifraga ciliata*, *Valeriana wallichii*. These MAP are difficult to be cultivated on commercial scale due to their long life cycle and temperate climatic reguirement which is harsh. These plants are to be managed and conserved accordingly in their natural habitats. The plants in group B, that can be cultivated as crops in the foot-hills and plains include: *Nigella sativa*, *Bunium persicum*, *Ocimum basilicum*, *Psoralea corylifolia*, *Fagopyrum esculantum*, *Lallemantia royleana*, *Datura fastuosa*, *Plantago ovate*, *Apium graveolens*, *Pimpinella anisum*, *Viola serpents*, *Hyoscymus niger*, *Mentha* spp., *Linum usitatissimum*, *Carum copticum*, *Ricinus communis*, *Matricaria chamomilla*, *Cichorium intybus*, *Cymbopogon citratus*, *Foeniculum vulgare*, etc.

In Pakistan, the production data of MAP is not regulated. The data on the production status of all types of MAP is neither collected nor reported by any Government agency. Particularly, the production statistics of Group A MAP is not available from any source. However, the Economic Wing in the Ministry of Food Security and Research, is collecting data on regular basis on the status of a few of the cultivated MAP, mainly Group B type plants (Table 1), which are primarily not the MAP but partly used as MAP.

Major Uses

Traditional Unani medicine system is a part of Pakistani culture. It was brought to the Indo-Pak sub-continent by Muslim scholars and practiced here for centuries. It also benefited from Ayurvedic system of medicine, which was an important component of Hindu civilization. Today traditional Unani medicine is popularly practiced among large segments (more than 50%) of Pakistan's population. It was recognized by the Government of Pakistan through the Act of Parliament "Unani, Ayurvedic and Homeopathic Act (1965)" amended in 1980. It has a provision of

Table 1. Area and production of the some cultivated MAP in Pakistan.

Botanical name	Area (000, ha)	Production (000 tons)
Allium sativum[*]	7.9	63.9
Coriandrum sativum[*]	5.9	2.9
Curcuma longa[*]	4.4	42.2
Cyamopsis tetragonoloba[*]	136.6	124.6
Foeniculum vulgare[*]	0.6	0.60
Linum usitatissimum[*]	47.29	2710
Pimpinella anisum[*]	0.3	1.2
Ricinus communis[*]	21.22	1133
Sesamum indicum[*]	101.0	50.7
Trigonella foenum-graecum L[*]	142.1	69.0
Zingiber officinalis[*]	37.0	27.0

Source: Agricultural Statistics of Pakistan, [*]Spices that are not primaily MAP

regulating the education and registration of practitioners. There are almost 50,000 traditional herbal medicine practitioners (Hakims or Tabeebs), mainly in the private sector. It is important to mention that traditional Unani medicines heavily depend on medicinal plants. Medicinal plants are used by the local people as sources of medicine. They use various parts of the plants such as roots, stem, bark, gum, leaves, fruit, seed, flowers for medicinal purposes, but the methods of application vary according to the tradition of different villages/communities. It is noted that the same plants are used in a number of different ways (Maheshwari and Bhandari, 1993). Some of the medicinal herbs and their uses are listed in Table 2.

Significant Achievements

Germplasm collection, characterization, conservation, and documentation

Agricultural research and development programs in Pakistan have been focused mainly on major crops and very little attention has been paid on other plants that are an integral part of rural ecosystem especially medicinal herbs. Major research activities on medicinal plants in Pakistan are at the documentation level. The research is being conducted mainly in universities and that too as ethnobotanical listing of resources. In Pakistan, more than 200 plant species are reported by Anderson (1988), which are used to treat various diseases including cough, kidney stone, stomach problems, malaria, hepatitis, urinary disorders, toothache, inflammation, skin problems, and pneumonia. Dymoke (1972), Ikram and Hussain (1978), Rehman *et al.* (1986) and Baquar (1989) contributed significantly to research on medicinal plants and ethnobotany in Pakistan.

Shinwari *et al.* (2006) published a pictorial guide of medicinal plants of Pakistan enlisting more than 500 species of flowering plants, being used as medicine. Athar and Siddiqui (2004) reported 95 species as medicinal plants from Pakistan. While several reports on ethnobotanical studies covering different geographical areas have been published, some important studies are

Table 2. Important MAPs to be used at primary healthcare level

S. No.	Species	Uses	S. No.	Species	Uses
1	*Aloe barbedensis*	Skin diseases	11	*Curcuma longa* L.	Gastro-intestinal tract problems
2	*Acacia nilotica* (Linn.)	Skin diseases, oral hygiene	12	*Plantago ovata* Forssk	Gastro-intestinal tract problems
3	*Morus nigra* L.	Sore throat	13	*Nigella sativa*	Hyperlipidemia
4	*Azadiracta indica* (L.)	Skin diseases	14	*Foeniculum vulgare* Miller	Gastro-intestinal tract problems
5	*Melia azadiracta*	Fever, skin diseases	15	*Carum copticum* (L.)	Gastro-intestinal tract problems
6	*Picrorhiza kurroo.*	Malaria, jaundice	16	*Thymus serpyllum*	Gastrointestinal ailments, bronchial problems
7	*Saussurea lappa.*	Sore throat	17	*Anchusa officinalis*	Irritation of stomach, bowls & bladder
8	*Rhazya stricta*	Urinary tract problems	18	*Origanum vulgare*	Amenorrhea, arthritis, glaucoma, emphysema, high blood pressure, HIV infection
9	*Adhatoda vesica* Nees	Asthma, coughs	19	*Achillium millefolium*	Diuretic, eczema, and catarrh from allergies, poultice on wounds
10	*Berberis lycium* Royle	Diarrheal diseases, HIV infection			

mentioned here. Shinwari and Gilani (2003) and Hamayun *et al.* (2006) listed medicinal plants from northern areas of Pakistan. Haq and Hussain (1993) reported 70 species of medicinal plants from Hazara, KPK province. Ali and Qaiser (2009) reported 83 taxa that were locally used in Chitral district of Hidukush range. Goodman and Ghafoor (1992) reported 171 species used as medicinal plants by communities in Kharan district, Baluchistan.

At present, research is being carried out in isolation in various institutes in the country and due to lack of proper information and coordination, a very little potential has been exploited. Major institutes involved in MAP research in the country are listed in Table 3.

Medicinal herbs particularly in the form of herbal medicines have been increasingly used worldwide during the last two decades because traditional medicine is well accepted and used by local people due to its accessibility, sustainability, affordability and cultural beliefs. Medicinal plants are potential economic boosters if developed and sustainable harvesting applied. Medicinal herb products in international trade generate more than US $ 20 billion annually. Genetic diversity of traditional MAP is continuously under the threat of extinction due to environment-unfriendly harvesting techniques and intermittent cultivation. Medicinal and aromatic plants are facing problems of a variety of nature. Most of the medicinal plants are harvested from the wild, or wild crafted. As the MAP trade has become market oriented, the growing number of wild crafters is outstripping natural populations. Mostly the collectors

Table 3. The major organizations involved in medicinal plant research

S. No.	Name of department	Organization	Research areas
1.	Deptt. Botany, Pharmacy, Chemistry & Pak. Forest Inst.	University of Peshawar, Peshawar	Ethnobotany, Taxonomy, Conservation, Documentation and Herb Garden
2.	ICCS, HEJ, Inst. Botany Dept.	Karachi University, Karachi	Phytochemistry, Pharmacology, Herbarium
3.	Hamdard Laboratories	Hamdard Karachi/Hamdard Univ., Karachi	Parmacology, Herbal Medicine Processing, Ethnobotany, Cultivation, Tissue culture
4.	Dept. Botany and Biochemistry	Baluchistan University, Quetta	Documentation and Analysis
5.	Qarshi Res. Institute	Qarshi Industries PVT Ltd.	Herbal Medicine processing, Collection & Herb Garden
6.	Dept. Plant Sciences and Chemistry	Quaid-i-Azam University, Islamabad	Ethnobotay, Chemical Analysis & Herbarium
7.	Dept. of Biological and Biomedical Sciences	Agha Khan Univ. Karachi	Pharmacology
8.	National Agricultural Research Centre, Islamabad	Pakistan Agricultural Research Council, Islamabad	Conservation, Propagation, Cultivation, Documentation, Biochemical Analysis, Herbarium
9.	Dept. of Botany and Chemistry	Kohat University of Science & Technology, Kohat	Documentation and Analysis
10.	National Institute of Health, Islamabad	Ministry of Health	Parmacology
11.	Pak. Council of Scientific & Industrial Research, Peshawar	Min. of Science & Technology	Phytochemistry
12.	Pak. Museum of Nat. History	Min. of Science & Technology	Taxonomy, Herbarium
13.	Department of Botany	Hazara Univ, Mansehra	Analysis
14.	Pharmacy Departments	Universities in Public Sector	Pharmacology
15.	WWF, Pakistan		Conservation
16.	IUCN, Pakistan		Conservation

of MAP are rural households, small and marginal farmers and collection is done by persons who have no training in the job and are without any supervision. Many of the drug plants have come into disrepute on account of haphazard collection, non-grading and improper care in drying and storage.

According to a study, nearly 37 per cent (266 species) of the total of 709 endangered species are endemic to Pakistan. The plant hot spots of Pakistan are spread over 13 natural regions from alpine pastures to mangrove forest. More than 10 per cent of the flora is endangered (Shinwari *et al.* 2002). Reasons of endangerment includes population pressure, poverty and poor quality

of natural resources-base, breakdown of social institutions, lack of land use plans, and lack of enforcement of existing rules in whatever form these are. In addition, rapid infrastructural development, spread of irrigation system, pollution and the destructive activities of the colossal influx of Afghan refugees also contribute towards threatening the resources (Shinwari, 2010). Recent influx of floods due to climate change have accelerated the process of negative impact on all PGR including MAP.

Pakistan is signatory to the Convention on Biological Diversity (CBD), FAO Undertaking 2002, Convention on International Trade in Endangered Species (CITES) and various others. Hence, Pakistan has put sincere efforts regarding conservation of its biological diversity including MAP. Ministry of Environment has drafted the Biodiversity Action Plan (BAP) in collaboration with diverse stakeholders involved. This action plan has proposed actions for *in situ* and *ex situ* conservation of its biodiversity including MAP. The Ministry of Environment has prepared a list of endangered and vulnerable MAP in Pakistan (Table 4).

Table 4. List of endangered and vulnerable MAP in Pakistan

Species	**Annual use (tons)**	**Ecological regions**	**Species**	**Annual Use (tons)**	**Ecological regions**
A. Endangered MAP species			**B. Vulnerable MAP species**		
Commophora wightii	20-25	Deserts	*Plantago ovata*	30-40	Cold arid hills
Picrorrhiza kurroo	10-15	Alpine Himalayas	*Pistacia integerrima*	2-3	Subtropical Himalayas
Podophyllum hexandrum	30-40	Temperate Himalayas	*Zizyphus sativa*	50-100	Sub-tropical Himalayas
Dioscoria deltoidea	30-60	Temperate Himalayas	*Glycyrrhiza glabra*	200	Hindukush, Karakorum
Paeonia emodi	10-20	Temperate Himalayas	*Artemisia* spp.	100-150	Hindukush, Karakorum
Onosma echoides	5-10	Cold dry mountains	*Adiantum capillusveneris*	80-100	Temperate Himalayas
Polygonum amplexicaule	15-20	Temperate Himalayas	*Acorus calamus*	20-30	Temperate Himalayas
Valeriana wallichii	30-35	Temperate Himalayas	*Mallotus philippensis*	5-10	Sub-tropical Himalayas
Aconitum heterophyllum	4-5	Temperate Himalayas	*Berberis lycium*	300-400	Hidukush, Himalayas
Rheum emodi	30-40	Temperate Himalayas	*Cochicum luteum*	5-8	Sub-tropical Himalayas
Saussurea costus	5-8	Alpine Himalayas	*Citrullus colocynthis*	40-50	Deserts
Atropa acuminata	15	Temperate Himalayas	*Bergenia ciliata*	15-20	Temperate Himalayas

Source: Biodiversity 2010 Targets, Ministry of Environment

Some of the medicinal herbs are also grown as minor crops particularly by small farmers to diversify their cropping system and to earn some additional income for their livelihood. Certain medicinal herbs like *Plantago ovata*, *Crocus sativus*, *Lallemantia royleana*, *Rosa damascena* and *Curcuma longa* are grown in particular ecologies. However, farmers involved in the cultivation of medicinal herbs are not fully aware of the production techniques.

Hence, a comprehensive action plan based on holistic approach is needed in the sustainable management of MAP to ensure the conservation of this biological diversity at the level of ecosystem, species and genetic resources. The concerns and issues relating to conservation of MAP could be addressed through a variety of activities involving government, NGOs, and other stakeholders. The general principles and procedures being recommended and adopted in Pakistan are, (i) *in situ* conservation and (ii) *ex situ* conservation.

In situ conservation

In Pakistan, 14 national parks have been established for *in situ* conservation, with the objective for conservation of biological diversity including MAP. The national parks and the area designated are given Table 5.

Table 5. National Parks and their areas

National park	Area (ha)	National park	Area (ha)
Ayubia	1,648	Kirthar	308,733
Chini	6,095	LalSohanra	37,426
ChitralGol	7,750	Margalla hills	17,426
Dhrun	167,700	Central Karakoram	-
Hazarganji-Chiltan	15,555	KandromSbandar	200 sq. miles
Hingol	165,004	Deosaiplanis	1400 sq miles
Khunjerab	22,913	Sheikh Buddin	-

Source: National Biodiversity Plan, Ministry of Environment

Ex situ conservation

The Ministry of Environment and Food Security and Research, Government of Pakistan provides funding through public sector development programs (PSDP) for this purpose. The following public and private organizations are involved in *ex situ* conservation through the promotion of good agricultural practices (GAP) in diverse environmental conditions and also they have established herbal gardens in various appropriate locations of the country: i) Plant Genetic Resources Institute, National Agricultural Research Centre (NARC), Pakistan Agricultural Research Council (PARC), Islamabad, ii) Pakistan Forest Institue (PFI), Peshawar, iii) Baluchistan Agricultural Research Centre (PARC), Quetta, iv) Mountain Agricultural Research Centre (PARC), Gilgit, v) Hamdard University, Karachi, vi) Qarshi Industries (200 exotic and local species are maintained in herbal garden), vii) Provincial Forest Departments, viii) Universities in public sector, ix) International Organizations, and x) Some NGOs.

Pakistan Agricultural Research Council (PARC) took initiatives in research and development of aromatic and medicinal plants. The initiatives helped in studying the genetic diversity of conserved germplasm of various aromatic and herbal species. Establishment of botanical gardens and collection of local germplasm of various herbal species from diverse ecologies broadened the gene pool of medicinal plants in Pakistan. A total of 989 accessions of 58 medicinal and herbal plant species were collected from diverse ecologies of Pakistan and/or acquired from abroad to broaden the gene pool of MAP species. Data on locally collected germplasm of some of the selected MAP are given in Table 6.

Table 6. Collection of germplasm of medicinal plants from diverse ecologies of Pakistan (2006-11).

Plant species	Accessions collected	Plant species	Accessions collected
Althaea officinalis	2	*Foeniculum vulgare*	30
Anethum graveolens	14	*Lallemantia royleana*	26
Amaranthus sp.	13	*Lawsonia inermis*	3
Carum copticum	32	*Linum usitatissimum*	32
Carthamus tinctorius	77	*Mucuna pruriens*	12
Cassia Absus	19	*Nigella sativa*	46
Cassia fistula	6	*Ocimum basilicum*	20
Cichorium intybus	28	*Papaver somniferum*	9
Coriandrum sativum	20	*Phyllanthus emblica*	15
Crotalaria juncea	3	*Plantago ovata*	32
Cuminum cyminum	18	*Punica granatum*	26
Curcuma longa	20	*Ricinus communis*	80
Cyamopsis tetragonoloba	150	*Sesamum indicum*	85
Eruca sativa	16	*Trigonella* sp.	31
Fagopyrum esculentum	2	*Vernonia anthelmintica*	20
Total			**897**

Efforts were also made to acquire germplasm of a number of aromatic flowering plants of economic importance from abroad such as Artemisia, chamomile, lavender, oregano, stevia, thyme, etc. Details of acquisition of germplasm of commercially important MAP from abroad are given in Table 7.

Characterization and evaluation

Germplasm of various medicinal herbs was characterized for agro-morphological traits under field and glasshouse conditions at NARC, Islamabad and out-stations for seed multiplication and identification of superior genotypes. A total of 2,203 accessions of various medicinal plants were characterized during 2006-11 (Table 8).

Table 7. Acquisition of germplasm of important medicinal plants and aromatic flowering plants from abroad (2006-11).

Herbal species	Source	Accessions	Herbal species	Source	Accessions
Aloe (Aloe barbedensis)	Local	3	*Myristica fragrans*	Unknown	1
Amaranthus sp	Local, China	13	*Jatropha curcas*	Unknown	2
Artemisia absinthium	Dutch	6	*Lavandula angustifolia*	Syria	1
Aegle marmelos	Local	1	*Cymbopogon citratus*	Local	1
Viola spp.	Local	3	*Euphoria longan*	China	2
Ocimum spp.	Thailand, UK, Japan, Russia, Egypt	14	*Mint* (*Mentha* spp.)	Canada, China, Japan, KSA, local	21
Borago officinalis	Canada	1	*Origanum vulgare*	Germany, Local	2
Apium graveolens	France	1	*Vinca rosea*	AJK	2
Matricaria chamomilla	China, Germany, Thailand	2	*Rosmarinus officinalis*	Unknown	1
Allium sativum	China	1	*Plectranthus amboinicus*	Thailand	2
Coriandrum sativum	China, Thailand	2	*Stevia rebaudiana*	Paraguay	1
Oenothera biennis	USA	1	*Thymus vulgaris*	Canada, Iran, USA, Kazakhstan	6
Camelina sativa	Local	1	*Thymus serpyllum*	Local	1
Paraax	China, Siberia, USA	3	*Wild Rose*	Germany	1
Lawsonia inermis	Local	1			
Total					**97**

More than 150 demonstration plots of various herbal species including *Matricaria chamomilla*, *Foeniculum vulgare*, *Cyamopsis tetragonoloba*, *Plantago ovata*, *Nigella sativa*, *Sesamum indicum*, *Linum usitatissimum*, *Trigonella* sp., *Carthamus tinctorius*, *Eruca sativa* and *Lallemantia royleana* were established at 172 locations in various districts of Punjab Province. Besides demonstration plots, germplasm of *Cyamopsis tetragonoloba*, *Plantago ovata*, *Linum usitatissimum*, *Carthamus tinctorius*, *Eruca sativa*, *Lallemantia royleana*, etc. was also characterized at 6 locations i.e. Arid Zone Research Institute, Bhakkar; Cholistan Institute of Deserts Studies (CIDS), Islamiya University, Bahawalpur; Guar Research Station, RARI, Bahawalpur; Neelibar Agricultural Research & Training Station (NARTS), Burewala and at farmers' fields for identification of better performing lines for Cholistan and Thal area.

Table 8. Characterization of elite lines of commercially important MAPs from 2006-07 to 2010-11.

S. No.	Crop species	Number of accessions characterized					
		2006-07	2007-08	2008-09	2009-10	2010-11	Total
1	*Carum copticum*	-	8	10	10	5	33
2	*Amaranthus* sp.	-	-	13	-	-	13
3	*Ocimum basilicum*	-	-	-	9	14	23
4	*Hippophae rhamnoides*	-	-	2	10	19	31
5	*Ricinus communis**	-	-	20	20	40	80
6	*Coriandrum sativum**	-	-	53	22	11	86
7	*Foeniculum vulgare**	-	6	7	5	10	28
8	*Zingiber officinale**	-	-	-	9	10	19
9	*Cyamopsis tetragonoloba**	116	57	100	101	-	374
10	*Plantago ovata*	22	96	-	95	95	308
11	*Nigella sativa*	82	99	-	15	20	216
12	*Linum usitatissimum**	46	55	40	22	30	193
13	*Trigonella* sp.	-	55	40	22	30	147
14	*Mentha arvensis*	-	-	-	10	21	31
15	*Carthamus tinctorius**	-	-	63	76	34	173
16	*Sesamum indicum**	141	19	20	105	12	297
17	*Eruca sativa**	-	-	5	5	105	115
18	*Lallemantia royleana**	-	-	-	65	64	129
19	*Curcuma longa*	-	-	4	20	-	24
	Grand Total	**407**	**395**	**377**	**621**	**520**	**2320**

**Species not used primarily as MAP*

Variety development

An early maturing and high yielding *Nigella sativa* variety NARC-Kalonji has been developed and approved for cultivation in Pakistan, while the process of registration of six promising lines one each of *Foeniculum vulgare*, *Plantago ovata*, *Linum usitatissimum*, *Trigonella* sp., *Eruca sativa*, and *Lallemantia royleana*, etc. is continued with Federal Seed Certification & Registration Department (FSC&RD), Islamabad, Pakistan.

Cultivation practices

The best way to ensure the sustainability of the plant material needed for medicine is through cultivation which does not deplete the wild populations. Declining the habitats of native plants can no longer meet the needs of local people and, also of the expanding market of medicinal plant products. Trials regarding production technology (i.e., fertilizer use, row spacing, sowing dates, etc.), propagation techniques (hormonal application for rooting, sowing media) and post-

harvest technology are being conducted for various medicinal and herbal species especially plants of economic significance under field and glasshouse conditions at NARC, Islamabad and are being demonstrated at farmers' fields. Seed germination studies have been conducted for *Stevia*. Seeds were sown in pots in different growing media such as sand, soil and peat. the maximum germination was recorded in sand but seedling vigour was relatively better in peat medium. Micropropagation of lavender, rosemary and *Stevia* was carried out. Optimized extraction of essential oil from mint varieties/species, *Cymbopogon citratus*, 13 *Ocimum cultivars*, *Geranium graveolens*, *Thymus vulgaris*, *T. serpyllum* and *Origanum vulgare* through distillation process, extracted polyphenols through methanol and hydro distillation process and analyzed through HPLC. Extracted essential oil from basil varieties (i.e., basil lime, garnet basil, holy basil, hot-wave basil, Italian basil and sweet basil), and thyme through hydro-distillation method. Main aim was to optimize agronomic requirement for herbal species and encourage farmers to adopt modern technology for herbal crops. By adopting technology package for medicinal plants, farmers may get substantial increase in their yield and earn extra money.

Production of quality seed and planting material

NARC-Kalonji (*Nigella sativa*) and promising genotypes of *Foeniculum vulgare*, *Cyamopsis tetragonoloba*, *Plantago ovata*, *Linum usitatissimum*, *Trigonella* (Methi), *Eruca sativa*, *Lallemantia royleana*, etc. being registered with Federal Seed Certification and Registration Department (FSC&RD), have been multiplied on larger scale at NARC for their seed increase and future distribution to the progressive growers in Pakistan (Table 9). High yielding and early maturing lines will be further multiplied and used as seed source in rainfed areas of country like Cholistan, Pothowar, and Thal, etc.

Table 9. Seed multiplication of registered varieties and selected lines of MAP

Crop species	2007-08	2008-09	2009-10	2010-11	Total
Carum copticum	1	1	1	1	4
Matricaria chamomilla	1	1	1	1	4
*Coriandrum sativum**	-	5	3	2	10
*Foeniculum vulgare**	1	1	1	1	4
*Cyamopsis tetragonoloba**	5	2	3	4	14
Plantago ovata	2	1	1	1	4
Nigella sativa	3	2	1	1	6
*Linum usitatissimum**	2	5	9	9	25
Trigonella sp. (Methi)	1	1	1	1	4
Trigonella sp. (Methray)	1	1	1	1	4
*Sesamum indicum**	2	2	10	5	19
*Eruca sativa**	-	-	1	1	2
Lallemantia royleana	1	1	1	1	4
Grand total	**20**	**23**	**34**	**29**	**104**

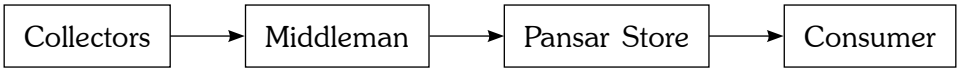
**Species not primarily for use as MAP*

Primary processing, value addition and product development

In Pakistan, only the private sector is involved in processing, value addition and product development. There are about 400 manufacturers of herbal marketable products in Pakistan. There are 125 firms or industrial units with Pakistan Tibbi Pharmaceutical Manufacturing Association (PTPMA). In Pakistan, Hamdard Laboratories (waqf), Qarshi Industries (Pvt.) Ltd., Herbion Pakistan (Pvt.) Ltd. and Ajmal Dawakhana are the major names in value addition and product development. On a small scale, some households and cottage industry are also involved in value addition and product development of MAP for local markets and their own consumption. The data on national health grid or statistics i.e. number of industrial facilities, manufacturers, importers, exporters, product type, price structure, sales and distribution of herbal products are not available.

Marketing, commercialization and trade

In Pakistan, large number of manpower is engaged in the business of MAP from its production, collection, distribution to its trade. Approximately 5,000 - 6,000 poor families residing in the remote hilly areas are engaged in the collection of MAP during summer months. The bulk of the collection is mostly done by local communities. There are two types of middlemen; large, who deal at national level marketing and the small ones who are generally present in the major MAP producing areas. Pansar stores are shops selling a variety of crude MAP material and manufactured products of various companies. In case of town level marketing of MAP, generally following channel is in operation:



MAP species are traded in a wide range of materials that are used in medicinal and health products in various forms or products. The trade structure of the MAP can be divided into three broad market sectors of supply – industrial, catering and retail. There are number of different routes to market, and the most direct is the producer supplying directly to the industrial sector. It is estimated that about 85 per cent of the international trade of MAP comprise dried and cleaned material for use in a crude form without further processing. Normally cultivators and collectors of MAP bring their produce to the nearest market, where it is sold to wholesalers directly or through the middlemen normally known as commission agents. These materials are transported to the bigger city markets to the wholesalers and from there the materials are either stored for export or sold out to retailers or supplied to the manufacturers. Sometimes, the demand comes from wholesale dealers who inform their agents for organizing the collection of the required materials. The agents contact small traders to send these items to wholesale dealers for purchase through commission agents. There are approximately 319 large wholesalers operating in the markets located in main cities such as Peshawar, Lahore, Karachi and Quetta.

Total value of medicines consumed in the country both imported and manufactured by national and multinational companies is over Rs. 100 billion per annum. Out of this, almost 90 per cent raw material is imported. However, very small quantities are also exported. Almost 250 plant species of medicinal herbs are being traded. There are about 86 registered manufacturers

of herbal medicine which consume most of the material. In the processing sector, almost 300 – 400 products are prepared based on MAP raw materials and extracts. Pakistan is involved in the export and import of large quantities of MAP. However, no economic analysis of MAP exists for marketing chain from collection to consumption. The trade in MAP is monopolized by wholesale drug dealers. The raw MAP are sold either dried or fresh to the local grocers who sell them to wholesalers who further sell them to the pharmaceuticals or to exporters. The trade of crude MAP is very erratic in Pakistan. Prices fluctuate greatly due to variations in external and internal demands within the country. Traders frequently underpay to collectors of the raw materials and sell the products at a large profit. Hence, the availability of particular crude MAP remains very unstable and market trends cannot be easily determined. The margin of profit earned by the traders is very large since they purchase the crude MAP at nominal rates from collectors and producers and obtain the maximum price from the consumers.

In Pakistan, national and multinational pharmaceutical companies import raw material of MAP. Data indicates a huge imbalance between export and import of Pakistan regarding MAP. The official data on the export and import of MAP is not published categorically. The data is only available in the form of "condiments" and under title of other spices all the MAP species are included. Their export and import are in crude forms and are generally listed in the "Foreign Trade Statistics of Pakistan".

Constraints and Opportunities

Constraints

- Diversity of medicinal plants is under threat and at the verge of extinction due to improper exploitation by collectors, deforestation, overgrazing, pressure from major crops and conversion of natural habitats to settlement in the hilly areas. Large-scale collection has also led to the depletion of traditional medicinal herbs in the area.
- Unlike major crops, limited research and development (R&D) work has been done on cultivation and improvement of medicinal plants in the country. Lack of proper cultivation methods for the local species contributes towards improper cultivation and harvesting, and hence, is the major cause of stagnation in the development of medicinal plants and herbs in Pakistan.
- Poor crop husbandry practices including poor harvesting and post-harvest practices pose serious problems.
- Non-availability of quality seeds of high yielding varieties with desired quality is a big constraint. There is lack of awareness among the farmers regarding commercial cultivation of medicinal plants. Poor post-harvest technologies and inefficient processing techniques lead to low yields and poor quality products.
- Non-availability of sufficient information on physiochemical parameters of cultivated medicinal plants by employing World Health Organization (WHO) and Association of the Agricultural Chemists (AOAC) guidelines.
- Non-availability of an efficient and effective extension system and incentives to encourage the farmers to grow medicinal plants is also a major constraint in development of MAP.

- Lack of education and training of collectors, growers and traditional medicinal practitioners create problem. The untrained collectors harvest natural resources mindlessly to subsidize their meager income. A large quantity (15%) of the material collected is wasted.
- Lack of coordination and linkages among various stakeholders of MAP sector, such as local communities, Government organizations, research institutes, private sector, NGOs and international organizations.
- There is lack of real statistics and database concerning the area and production of MAP.
- There is uncertainty and discriminating prices to the growers and collectors by market forces.

Opportunities

- Pakistan is gifted with rich flora of medicinal and aromatic plants due to its varied ecological conditions. These MAP have immense pharmaceutical potential which need to be exploited.
- Traditional Unani medicine system heavily relies on use of different plant parts in prevention and cure of diseases. More than 80 per cent population of the country resorts to such crude drugs of vegetable origin.
- The hot spots of medicinal plants are spread over 13 natural regions. There is good scope to exploit these hotspots appropriately for collection and utilization of MAP species.
- Implementation of R&D programs involving Govt. agencies, institutions and private sector is likely to pay good dividends for MAP sector
- The herbal materials are usually supplied in crude form to the dealers. However, if the plants are processed into a consumer usable form, the value added product would fetch higher income for the collectors/cultivators as compared to unfinished material.

Approaches for Meeting Emerging Challenges

Exploration, collection and preservation of indigenous MAP: Exploration and collection of medicinal plant resources were performed especially in northern areas. Seeds of sizable number of accessions of identified MAP have been conserved in the genebank at PGRI, NARC. Perennials and vegetatively grown plants are being maintained in Herb Garden at NARC.

Evaluation of genetic resources: Genetic resources collected, multiplied and conserved in the genebank are being evaluated for agronomic characteristics and some of these are also subjected to various laboratory studies.

Promotion of local activities for medicinal plant conservation: Conservation of MAP in their natural habitats can only be achieved through the intensive involvement of local communities as well as local public sectors. Workshops were held and demonstration plots established to promote the MAP conservation activities.

***In situ* conservation and its linkage with industries:** The reproductive process of many medicinal plant species is not well analyzed. Unlike majority of crop plant species, most of medicinal plant accessions conserved *ex situ* cannot represent the species in general, nor their genetic sustainability ensured. Genetically heterogeneous populations are apt to be subject to genetic drift under the selection pressure, abiotic or biotic. This situation makes the *in situ* conservation far more important than in the case of most of crop plants. How to make the conservation by local communities sustainable is a major issue of the conservation of natural habitat.

Promotion through public awareness: The PGRI originally and exclusively established for crop plants stepped into the conservation and culture of medicinal plants in 1990s and strengthened the linkages within NARS and enhanced the public awareness on the medicinal plant resources conservation.

Future Thrusts

Greater thrusts need to be placed on the following for promotion of MAP species:

- Acquisition, distribution, exchange and characterization of germplasm
- Varietal development and seed production of selected MAP
- Propagation and distribution of MAP through seed and stem cuttings.
- Development of production technologies for local and exotic germplasm
- Promotion and dissemination of improved production technology of MAP
- Value addition to raw material
- Scientific confirmation of indigenous knowledge.
- Sustainable use of MAP
- Biochemical anti-microbial analyses of indigenous MAP

Conclusion

Pakistan, like other countries of the world is faced with the threat of genetic erosion of MAP and more than 10 per cent of the flora is endangered. The reasons for endangerment include population pressure, poverty and poor quality of natural resource base. Breakdown of social institutions, rapid infrastructural development, deforestation, spread of irrigation system, pollution and destructive activities of the colossal influx of Afghan refugees adversely affected the use of MAP. Over-harvesting of medicinal plants for commercial purpose has also threatened the abundance and even occurrence of the major MAP. Unfortunately, not much efforts have been made towards the cultivation of MAP. There is an urgent need to improve the situation and regularize the cultivation, harvest, marketing and processing of MAP in the country. There is also a need to update the inventory of the existing medicinal plants of the country, and mapping of MAP regarding their growth in wild for sustainable supply. Selection of potential medicinal plants, their cultural practices, *in situ* and *ex situ* conservation, variety development/ improvement, phytochemical analysis and biological testing, training of communities involved in collection, propagation and cultivation, marketing analyses, value addition of MAP and

develop linkages among producer and the industry, need to be paid urgent attention. There is also a need to encourage and support the cultivation of improved and good quality MAP on commercial scale for their continued availability, promote environmental protection and conservation of medicinal plants, and establish small extraction and pharmaceutical units for preparation of value added products from a number of unexploited plants available in sizeable quantities in the various parts of the country. A national policy on traditional medicinal and aromatic plants need to be developed on priority in order to promote the use of medicinal and aromatic plants in the country.

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Country Status Report on Medicinal and Aromatic Plants in Sri Lanka

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Introduction

Sri Lanka is located in the tropical belt close to the equator between 5°.55'-9°.50' longitude and 79°.42'-81°52' latitude. The area is 65,610 km^2 and the topography varies from flat lowland to a mountainous region up to 2,500 m altitude. Mean annual temperature ranges between 20°C-28°C' while mean annual rainfall varies between 1,000-3,000 mm.

On the basis of rainfall and temperature pattern, the country is divided into four regions, namely, arid, dry, intermediate and wet zones. The arid zone has a temperature between 32-36°C. The rainfall is below 100 mm per year and the altitude is less than 300 m asl. The forest type is referred to as Tropical Thorn Scrub. The dry zone has a temperature range of 28-32°C. The rainfall is between 1,000-1,500 mm per year and the altitude is less than 500 m asl. The forest type is referred to as Tropical Dry Mixed Evergreen. The intermediate zone has a temperature between 24-28°C. The rainfall is between 1,250-2,000 mm per year and the altitude is between 500-1,500 m asl. The forest type is referred to as Tropical Moist Evergreen. The wet zone has a temperature between 16-28°C. The rainfall is above 2,000 mm per year and the altitude range is divided in to three categories.

There are a number of vegetation types: Tropical Lowland Wet Evergreen forests in wet zone of the altitude ranging between 300-1,000 m asl, Tropical Sub-Montane forests in altitude ranging between 900-1,500 m asl and Tropical Upper Montane forests in the altitude above 1,500 m asl.

Sri Lankan Flora

The plant community of Sri Lanka consists of around 214 families 1,522 genera and 4,143 species of flowering plants. Among them, 75 per cent are indigenous and 25 per cent are exotic species. Of the total number of indigenous species, 27.5 per cent are endemic. Of the exotics, 32 per cent are naturalized and 68 per cent are under cultivation. Sri Lanka is one of the warmest places of biodiversity in the world. A total of 3,368 flowering plant species are recorded to be found in Sri Lanka. Among them, 487 (14%) are facing threat of extinction. In the forests of the country, 879 endemic species are recorded and 14 per cent of these have been included in the Red Data List of Sri Lanka.

During the last 100 years, about 100 plant species have disappeared for ever. Nearly 16 per

cent of flowering plants, 28 per cent of ferns and allies are affected as a result of human. Thus, these plants are grouped under endangered plants. For example, intervention out of 480 flowering plants, 228 are endemic; 30 out of 90 ferns are endemic; 99 orchids out of 170 are native species. Also, many medicinal plants and timber species are subjected to threat of extinction. Overexploitation, habitat degradation, deforestation, fragmentation, pollution and introduction of alien invasive species are the leading causes of mass extinction of these species.

Medicinal plants

In Sri Lanka, most of the medicinal plants are grown in forests or forest related areas. About 1,500 medicinal plant species are being used in Sri Lanka and 180 of these are endemic. About 1,430 species of medicinal plants have been identified in the country at present. Among them, 600 species are used commonly and 208 species are frequently used in Ayurveda. The medicinal plants commonly used in Sri Lanka are given in Table 1.

Table 1. Medicinal plants commonly used in Sri Lanka

Local name	Botanical name	Local name	Botanical name
Aba	*Brassica juncea* (L.) Czern.	Kalaanduru	*Cyperus rotundus* L.
Adathoda	*Justicia adhatoda* L.	Kalawel	*Dallbergia lanceolaria* L.f.
Aga mulanatiwel	*Cuscuta chinensis* Lam.	Kalukammeriya	*Silanum americanum* Mill.
Aga mulanatiwela	*Cuscuta reflexa* Roxb.	Kapparawalliya	
Ahu	*Morinda citrifolia* L.	Kapu	*Gossypium arboreum* L.
Akkapana	*Kalanchoe pinnata* (Lam) Pers.	Kapukinissa	*Abelmoschus moschatus Medik*
Alabeth	*Gynura pseudo-china* DC.	Karaabu	*Syzygium aromaticum* (L.) *Merrand* Perry.
Alupuhul	*Benincasa hispida* (Thunb.) Cogn.	Karalhaba	*Achyranthes aspera* L.
Amba	*Mangifera indica* L.	Karapincha	*Murraya koenigii* (L.) Spreng.
Ambul-dodam	*Citrus aurantium* L.	Katakela	*Bridelia retusa* (L.) A. Juss.
Amukkaraa	*Withania somnifera* (L.) Dunal.	Katarolu	*Clitoria ternatea* L.
Anitta	*Rhinacanthus nasutus* (L.) Kurz.	Katuanoda	*Annona muricata* L.
Ankenda	*Acroncychia pedunculata* (L.) Miq.	Katukarandu	*Barleria prionitis* L.
Aruda	*Ruta graveolens* L.	Katupila	*Flueggea leucopyrus* Willd.
Asamodagam	*Trachyspermum roxburghianum* (Wall.) Craib.	Katurupila	*Tephrosia purpurea* (L.) Pers.
Asoka	*Saraca asoca* (Roxb.) De Wilde.	Katuvelbatu	*Solanum virginianum* L.
Aswenna	*Alyssicarpus vaginalis* L.DC.	Kekatiya	*Aponogeton crispus* Thunb.
Athdemata	*Gmelina arborea* Roxb.	Kelinda	*Holarrhena antidysenterica* (Roxb.) Wall

Contd...

Table 1 (contd...)

Local name	Botanical name	Local name	Botanical name
Atividayam	*Aconitum heterophyllum* Wall.	Kidaaram	*Amorphophallus paeoniifolius* (Dennst.)
Atteriya	*Murraya paniculata* (L.) Jack.	Kikirindiya	*Eclipta prostrata* L.
Attikkaa	*Ficus recemose* L.	Kirianguna	*Wattakaka volubilis* (L.f) Stapf.
Badi del	*Artocarpus nobilis* Thw.	Kiribadu	*lpomoea mauritiana* Jacq.
Badulla	*Semecarpus coriacea* Thw.	Kobbae	*Allophylus cobbe* (L.) Rausch.
Baduraa	*Nepenthes distillatoria* L.	Kobolila	*Bauhinia purpurea* L.
Beli	*Aegle marmelos* (L.) Correa	Kohila	*Lasia spinosa* (L.) Thw.
Beth Anoda	*Abutilon indicum* (L.) *Sweet* ssp. *guineense* (Schum.) *Borssumwaalkes*	Kohomba	*Azadirachta indica* A. Juss.
Bilin	*Averrhoa bilimbi* L.	Kokum	*Kokoona zeylanica* Thw.
Bim pol	*Trichopus zeylanicus* Gaertn.	Kollankola	*Pogostemon heyneanus* Benth.
Bin nuga	*Tylophora indica* (Burm.f.) Merr.var.indica.	Komarika	*Aloe vera* (L.) Burm.f.
Bindadakiriya	*Euphorbia thymifolia* L.	Kontaalam	*Xylocarpus rumphii* (Kostel.) Mabb.
Binkohomba	*Munronia pinnata* (Wall.) Theob.	Kotalahimbutu	*Salacia reticulata Wight*
Bintaburu	*Ipomoea pes-caprae* (L.) R.Br.	Kumbhuru	*Caesalpinia bonduc* (L.) Roxb.
Bintal	*Curculigo orchioides* Gaertn.	Kumbuk	*Terminalia arjuna* (Roxb.) *Wight* and Arn.
Bokala	*Derris scandens* (Roxb.) Benth.	Kuppameniya	*Acalypha indica* L.
Bombu	*Symplocos cochinchinesis* (Lour.) S. Moore.	Lolu	*Cordia dicotoma* Forst. f.
Bomi	*Litsea glutinosa* (Lour.) *C.B. Robinson*	Lunuwarana	*Crateva adansonii DC.* ssp. *odora* (Buch.-Ham.) *Jacobs*
Bulath	*Piper betle* L.	Lunuwila	*Bacopa monnieri* (L.) Pennell.
Bulu	*Terminalia bellirica* (Gaertn.) Roxb.	Maadan	*Syzygium cumini Skeels*
Burulla	*Leea indica* (Burm.f.) Merr.	Magulkaranda	*Pongamia pinnata* (L.) *Pierre*
Butsarana	*Canna indica* L.	Maila	*Bauhinia racemosa* Lam.
Daaruharidraa	*Berberis aristata* DC.	Makulla	*Hydnocarpus venenata* Gaertn.
Daluk	*Euphorbia antiquorum* L.	Malitha	*Woodfordia fruticosa* (L.) Kurz
Datkatiya	*Ophiorrhiza mungos* L.	Malla	*Olax zeylanica* L.
Datta	*Baliospermum montanum* (Willd.) Muell.Arg.	Manel	*Nymphaea nouchali* Burm.f.

Contd...

Table 1 (contd...)

Local name	Botanical name	Local name	Botanical name
Daulkurundu	*Neolitsea cassia* (L.) Kosterm.	Masbedda	*Gymnema sylvstris* (Retz.) R.Br. exSchult.
Dehi	*Citrus aurantifolia* (Christm. and Panzer) Swingle.	Midella	*Barringtonia acutangula* (L.) Gaertn.
Delum	*Punica granatum* L.	Milla	*Vitex pinnata* L.
Divikaduru	*Pagiantha dichotoma* (Roxb.) Markgraf.	Mudamahana	*Sphaeranthus indicus* L.
Diyahabarala	*Monochoria hastata* (L.) Solms-Laub	Mukunuwenna	*Alternanthera sessilis* (L.) DC.
Diyamitta	*Cissaampelos pareira* L.var. hirsuta (Buch.ex.DC.) Forman.	Munamal	*Mimus opaelengi* L.
Dombha	*Callophyllum inophyllum* L.	Murunga	*Moringa oleifera* Lam.
Duhudu	*Celastrus paniculatus* Willd.	Nawahandiya	*Rhipalis baccifera* (J.S. Mueli) Stearn.
Dummella	*Trichosanthes cucumerina* L.	Nelli	*Phyllanthus emblica* L.
Ekaaweriya	*Rauvolfia serpentina* (L.) Benth ex Kurz	Nika	*Vitex negundo* L.
Elabatu	*Solanum melongena* L.	Nil-awariya	*Indigofera tinctoria* L.
Ella		Niyanda	*Sansevieria zeylanica* (L.) Willd.
Enasahal	*Elettaria cardamomum* (L.) Maton, Var major Thw.	Palol	*Stereospermums uaveolens* DC
Erabadu	*Erythrina variegata* L.	Pambha	*Lygodium flexuosum* (L.) Sw.
Et-adi	*Elephanto pusscaber* L.	Pitasudusaarana	*Boerhavia diffusa* L.
Et-tora	*Cassia alata* L.	Pitawakka	*Phyllanthus amarus* Schum.
Gammalu	*Pterocarpus marsupium* Roxb.	Polpala	*Aerva lanata* (L.) Juss.exSchult.
Gammiris	*Piper nigrum* L.	Prasarini	*Paederia foetida* L.
Gansuriya	*Thespesia populnea* (L.) Soland.ex Correa	Pupula	*Vernonia zeylanica* (L.) Lees.
Gas nidikumbaa	*Biophytum reinwardtii* (Zucc.) Klotssch	Puswel	*Entada pursaetha* DC.
Gatatumbha	*Leucas zeylanica* (L.) R.Br.	Puwak	*Areca catechu* L.
Godakaduru	*Stychno snux-vomica* L.	Ranavaraa	*Cassia auriculata* L.
Godapara	*Dillenia retusa* Thunb.	Rankirigokatu	*Argemone mexicana* L.
Gon-kakiri	*Cucumis melo* L.	Rasakinda	*Tinospora cordifolia* (willd) Hook. Fand Thoms

Contd...

Table 1 (contd...)

Local name	Botanical name	Local name	Botanical name
Goraka	*Garcinia quaesita* Pierre.	Rathandun	*Pterocarpus santalinus* L.f.
Gotukola	*Centella asiatica* (L.) Urban.	Ratnitul	*Piumbago indica* L.
Guranda	*Celtis timorensis* Span.	Rukanguna	*Alangium salviifolium* (L.f) *Wangerinssp.salviifolium*
Harankaha	*Curcuma zedoaria* (Christm.) Roscoe	Rukattana	*Alstonia scholaris* (L.) R.Br.
Hataawariya	*Asparagus racemosus* Willd.	Sadikka	*Myristica fregrans* Houtt.
Heen midi	*Premna obtusifolia* R.Br.	Samanpicha	*Jasminum officinale* L.
Heenaratta	*Alpinia calcarata* Roscoe.	Sapsanda	*Aristolochia indica* L.
Heenbabila	*Sida alnifolia* L.	Senehekola	*Cassia senna* L.
Heenbinkohomba	*Andrographis paniculata* (Burm.f.) Wall.ex Ness var. paniculata	Sera	*Cymbopogon citratus* (DC.) Stapf.
Heenmadurutala	*Ocimum tenuiflorum* L.	Sevendaraa	*Vetiveria zizanioides* (L.) Nash
Heennerenchi	*Tribulus terrestris* L.	Siviya	*Piper chuvya* (Miq.) C.DC.
Heerassa	*Cissus quadrangularis* L.	Suduhandun	*Santalum album* L.
Hulankiriya	*Maranta arundinacea* L.	Sudulunu	*Allium sativum* L.
Ikiriya	*Hygrophila schulli* (Buch-Ham) M.R. and S.N. Almeida	Tarana	*Tarenna asiatica* (L.) Kuntze ex Schumann
Imbul	*Bombax ceiba* L.	Tebu	*Costus speciosus* (Koenig) Smith
Inguru	*Zingiber officinale* Roscoe.	Tippili	*Piper longum* L.
Ingurupiyali	*Kaempferia galanga* L.	Tirassavalu	*Operculina turpethum* (L.) S. Manso
Iramusu	*Hemidesmus indicus* (L.) R.Br.	Tolabo	*Crinum asiaticum* L.
Iriweriya	*Plectranthus zeylanicus* Benth.	Totila	*Oroxylum indicum* (L.) Vent.
Jayapala	*Croton tiglium* L.	Vadakaha	*Acorus calamus* L.
Kabarossa	*Smilax zeylanica* L.	Valmadata	*Rubia cordifolia* L.
Kabella	*Aporus alindleyana* (Wight) Baill.	Vanduru-mae	*Mucuna pruriens* (L.) DC.
Kadupahara	*Emilia exserta Fosberg*	Varaa	*Calotropis gigantea* (L.) R.Br.
Kaha	*Curcuma longa L.*	Vellangiriya	*Capparis zeylanica L.*
Kaha-adanahiriya	*Crotalaria retusa* L.	Veniwel	*Coscinium fenestratum* (Gaertn.) Colebr.
Kahabiliya	*Tragia involucrata* L.	Visnukranti	*Evolvulus alsinoides* (L.) L.
Kahata	*Careya arborea* Roxb.	Monarakudumbiya	*Varnonia cinerea* (L.) Less.
Kahipittan	*Cycleapeltata* (Burm.f.) Hook.f. and Thoms.		

Aromatic plants

Sri Lanka is blessed with a rich biodiversity and has inherited an ideal ecological diversity for cultivation of aromatic plants. Aromatic plants have been used for thousands of years for many different purposes ranging from medicinal to religious; from protection against spirits to culinary delights. In this report, aromatic plants of economic value have been dealt with.

In Sri Lanka, *cinnamon* seems to have originated in the central hills where seven wild species of *cinnamon* occur in Kandy, Matale, Belihulloya, Haputale, Horton planes and the Sinharaja forest range. Pepper is mainly cultivated in low and mid country, wet and intermediate agro-climatic zones. Clove is mainly grown in mid country wet zone of Sri Lanka concentrated in Kandy, Kegalle and Matale districts which are the major growing areas. Cultivation of *Citronella* restricted to is Hambantota and Rathnapura districts (Fig.1). The cultivation is mainly in Kurunagala, Kandy, Gampaha, Colombo and Kegalle districts. In the Western Province, ginger is largely grown as an inter-crop with coconut and as a home garden crop. Lemon grass is reported to have been grown in Badulla and Hambanthota area but no exact evidence on the extent could be found. Based on the available information, it is estimated that the total area under lemon grass in Sri Lanka is less than 25 ha. Nutmeg prefers cooler climates; hence mid country areas of Sri Lanka are ideal for the growth of nutmeg. Other major growing areas are Kegalle and Matale districts. Major turmeric growing districts are Kurunagala, Gampaha, Kalutara, Kandy and Matale districts. In Sri Lanka, vanilla is mainly confined as a home garden crop grown in mid and low country wet zone.

Fig. 1. *Geographical map of Sri Lanka (Source: Epotopix.com)*

The medicinal and aromatic plants of Sri Lanka which are of economic value are exported and are referred to as export crops. The production and estimated extent of export and export volume and value of export agriculture crops are presented in Tables 2-5.

Table 2. Extent of cultivation and utilization of export crops in Sri Lanka (2009)

Crop	Area (ha)	Utilization (tons)
Cinnamon (leaf oil, bark oil)	29,415	2174.3
Nutmeg (mace)	926	683
Cardamom (oil)	2,794	49.5
Cloves (stem, oil)	7,611	538.5
Citronella	1,102	4.7

Source: Department of Agriculture, Administrative Report, 2010

Table 3. Estimated production of export of agriculture crops (2009-2012)

Crop	Production (tons)			
	2009	2010	2011	2012
Cocoa	467	520	525	513
Coffee	3,125	3,164	2,974	3,000
Cinnamon	15,765	16,435	18,250	17,165
Pepper	15,767	17,332	10,834	18,604
Cardamom	61	48	57	80
Clove	3,032	9,551	5,533	4,009
Nutmeg (and mace)	1,740	2,376	2,116	2,002
Arecanut	23,540	24,361	24,485	23,450
Betel	30,454	30,046	30,645	28,200
Citronella oil	7	19	9	13
Ginger (raw)	10,780	12,052	13,663	14,911
Turmeric (raw)	7,747	8,304	9,308	8,708

Source: Dept. of Census and Statistics and DEA database.

Table 4. Estimated area of export agriculture crops (2008 – 2012)

Crop	Area (ha)				
	2008	2009	2010	2011	2012
Cinnamon	28,971	29,486	30,106	30,523	31,049
Pepper	30,156	30,528	30,931	31,296	31,667
Cloves	7,608	7,613	7,603	7,605	7,612
Cardamom	2,785	2,794	2,795	2,795	2,798
Coffee	5,926	5,958	6,008	6,040	6,093
Cocoa	2,513	2,253	2,279	2,300	2,336
Nutmeg	914	927	946	954	973
Betel	2,505	2,735	3,071	3,086	3,253

Contd...

Table 4 (contd...)

Crop	Area (ha)				
	2008	**2009**	**2010**	**2011**	**2012**
Areca nut	13,837	14,219	15,082	15,094	15,844
Citronella	1,083	1,123	1,171	1,180	1,177
Total	**96,299**	**97,636**	**99,992**	**100,873**	**102,802**

Source: General Report of the Census of Agriculture, 2002 and Progress Reports of DEA Agricultural Statistics by Dept. of Census and Statistics

Table 5. Volume and value of export of agriculture crops (2008-2012)

Export crops		Units	2008	2009	2010	2011	2012
Commodities							
Cinnamon	Volume	tons	12,273.0	12,110.2	11,775.7	13,485.3	14,435.0
	Value	Rs(Mn)	8,948.0	8,517.6	9,369.1	13,394.4	16,654.7
Cin-leaf oil	Volume	tons	179.0	107.2	155.4	231.2	318.2
	Value	Rs(Mn)	262.2	143.0	244.4	498.6	482.7
Cin-bark oil	Volume	tons	7.0	16.8	26.0	30.1	9.0
	Value	Rs(Mn)	157.9	133.4	251.6	351.0	259.5
Clove	Volume	tons	6,136.3	2,315.2	6,833.0	3,570.5	1,427.0
	Value	Rs(Mn)	3,507.4	1,333.6	4,084.7	3,676.3	2,092.1
Clove stem	Volume	tons	1,267.7	600.1	1,482.8	1,624.9	1,487.1
	Value	Rs(Mn)	68.4	45.9	137.2	235.3	247.7
Clove oil	Volume	tons	8.9	1.5	14.6	13.0	3.7
	Value	Rs(Mn)	34.2	11.2	41.1	45.6	33.0
Cocoa & proudcts	Volume	tons	444.2	1,601.1	4,176	5,190.3	3,426.7
	Value	Rs(Mn)	132.1	775.0	2,089.7	2,688.5	2,182.6
Coffee	Volume	tons	85.6	60.1	157.5	10.4	9.6
	Value	Rs(Mn)	25.8	15.3	38.1	8.7	8.0
Pepper	Volume	tons	6,236.8	6,576.1	12,218.9	5,056.7	10,487.3
	Value	Rs(Mn)	2,841.3	2,365.6	4,824.8	3,391.4	8,904.4
Pepper oil	Volume	tons	15.9	3.8	5.3	8.6	12.3
	Value	Rs(Mn)	11.9	32.3	41.6	151.2	278.9
Cardamom	Volume	tons	12.1	9.2	6.9	11.5	10.5
	Value	Rs(Mn)	29.0	27.9	30.6	65.4	32.2
Cardamom oil	Volume	tons	0.4	0.2	0.3	1.6	0.9
	Value	Rs(Mn)	17.8	14.5	16.7	75.1	43.5
Citronella	Volume	tons	22.3	7.3	18.5	11.7	12.6

Contd...

Table 5 (contd...)

Export crops		Units	2008	2009	2010	2011	2012
	Value	Rs(Mn)	50.3	21.2	44.1	28.6	28.2
Lemon grass oil	Volume	tons	2.4	1.5	1.9	1.3	0.5
	Value	Rs(Mn)	6.4	5.6	6.4	4.6	1.9
Nutmeg	Volume	tons	1,581.2	1,401.3	1,952.0	1,669.0	1,390.2
	Value	Rs(Mn)	788.4	717.1	1,358.7	2,067.9	1,948.8
Mace	Volume	tons	177.4	205.5	244.8	205.0	192.1
	Value	Rs(Mn)	182.6	212.3	445.3	756.0	578.9
Nutmeg oil	Volume	tons	34.8	10.2	13.0	22.2	25.9
	Value	Rs(Mn)	44.6	68.2	94.3	235.5	333.8
Vanila	Volume	tons	0.5	0.02	0.3	0.2	0.3
	Value	Rs(Mn)	0.8	0.7	4.7	5.3	4.6
Vanila oil	Volume	tons	0.04		0.01	0.03	
	Value	Rs(Mn)	0.03		0.03	0.1	
Arecanut	Volume	tons	3,050.0	1,425.8	1,984.1	2,176.4	2,120.6
	Value	Rs(Mn)	367.1	157.5	246.6	273.8	408.4
Betel	Volume	tons	3,002.2	2,591.3	2,246.4	2,845.0	1,934.2
	Value	Rs(Mn)	720.6	687.9	576.1	758.8	637.7
Mace oil	Volume	tons	0.01		0.1	0.003	0.002
	Value	Rs(Mn)	0.1		0.5	0.044	0.028
Total	**Volume**	**tons**	**34,537.9**	**29,044.4**	**43,313.0**	**36,165.0**	**37,303.5**
	Value	**Rs(Mn)**	**18,196.8**	**15,285.9**	**23,946.2**	**28,712.1**	**35,161.5**
Ginger & Turmeric							
Ginger	Volume	tons	59.0	44.6	36.7	138.8	194.5
	Value	Rs(Mn)	42.6	38.7	46.5	152.0	122.9
Ginger oil	Volume	tons	1.9	1.6	0.9	1.1	0.9
	Value	Rs(Mn)	15.4	5.6	14.4	17.7	13.2
Turmeric	Volume	tons	54.8	18.6	13.3	31.1	29.2
	Value	Rs(Mn)	39.5	14.2	11.2	30.8	23.9
Total	**Volume**	**tons**	**115.6**	**64.8**	**51.0**	**171.0**	**224.6**
	Value	**Rs(Mn)**	**97.4**	**58.5**	**72.0**	**200.6**	**160.0**

Source: Sri Lanka Customs with re-exports

Major Uses

Cinnamon: Cinnamon bark is widely used as a spice. Cinnamon chips are used to obtain oil with 30-55 per cent cinnamic aldehyde content. Cinnamon quills and quillings are used to produce oil with a much higher cinnamic aldehyde content and a finer aroma. The cinnamon bark oil is obtained from the inner stem bark. Cinnamon leaf oil is regarded mainly as a by product in the processing of cinnamon.

Pepper: Small amount of green and ripened pepper is pickled in brine and dehydrated green pepper and preserved red pepper is traded. Pepper oil and oleoresins are also extracted and marketed as value added products. Pepper is mainly used as a spice and flavouring agent in food industry.

Cardamom: Cardamom is mainly used in the food industry as a flavouring agent in curry or meat dishes, sweets, confectionaries, in bakery products, and as an ingredient of curry (masala) powder. Cardamom oil is used for flavouring of beverages and drinks such as coffee and tea.

Clove: Clove is largely used as dried whole buds. Ground clove is used for curry mixtures. Cloves are used either whole or ground to provide flavour for both sweet and savoury foods in pickling and the production of sauces and ketchups. In medicine, it is valued as a carminative, aromatic and stimulant.

Citronella: The oil extracted from leaves and other aerial parts of the plant is the commercial product of importance. *Citronella* oil is used as a fragrant in cosmetic industry, soap and detergent manufacturing, polish, paint and in insecticide industry. It is a common mosquito repellent and also used in indigenous medicine.

Ginger: Ginger is available in market as fresh ginger or in dry form. Dried ginger is powdered and used for different products. Pickled fresh ginger is popular in East Asian countries and salted and sweetened ginger products are also commonly available in the Asian markets. Ginger oils and oleoresins are used in the food industry as a spice to flavour curries, bakery and other food products and to some extent in the perfumery industry, Also, it is a common ingredient in the Ayurveda medical system till today.

Lemon grass: It is used for oil extraction as well as in production of detergents, disinfections and deodorizing compounds and as flavouring agent in ice creams, cakes, beverages, confectionaries and puddings and chewing gums.

Nutmeg and mace: Nutmeg and mace are the main two products. Oils are extracted from both nutmeg and mace. Powdered nutmeg and mace are used in curry powders. Nutmeg and mace are mainly used for culinary purposes to flavour curries and other food products, confectionaries and bakery products. It is also used in preparation of beverages and drinks. Nutmeg is used as an ingredient in Ayurvedic medicine.

Turmeric: It is also used as an ingredient in preparation of curry mixtures. Oils and oleoresins are extracted from turmeric which is mainly used as colouring and flavouring agent in the food industry. Turmeric is mainly used as a flavouring and colouring agent in the food industry. It is also used as a colouring in textiles and preparation of specific paints. In Ayurvedic medicine, turmeric is a common ingredient.

Vanilla: Vanillin is the main product extracted from vanilla. It is used as a flavour ingredient in confectionery industry, perfumery and pharmaceutical industries.

Achievements

Among the plant population of the world, only limited number of plants (about 5-10%) are used in the preparation of bioactive herbal formulations or other commercially important products. Thus, only a smaller portion of herbal plants have so far entered the plant based international

drug market. However, the supply of nutritious foods and health related products to the foreign market are being paid due attention. Accordingly, at present Sri Lanka is gradually gaining popularity in the export of indigenous plants and related products to the foreign market.

Constraints and Opportunities

Constraints

Maintaining the quality of drugs, standardization, the relevant rules and limitations and economic background are the main obstacles encountered in the process of production and sale of drugs for the foreign market. For developing countries like Sri Lanka, it is not an easy task to conform to such conditions.

Opportunities

There is need for looking at new plant sources for use as MAP spices and their products need to be paid greater attention. Prospects for enhanced use of essential oils are bright and hence, concerned research and development work needs to be undertaken on MAP.

Future Thrusts

The world is currently experiencing a resurgence of plant derived materials. The interest toward organically grown food, herbal and traditional medicinal material is growing. Sri Lanka has a mini climatic zone that produces raw materials sometimes better than our competitors e.g. pepper, cinnamon, cloves and cardamom. Future thrusts for promotion of medicinal and aromatic plants are given below:

- There is an urgent need to improve the productivity through concerted research and extension. National economic policy which is an important aspect should be given priority attention to facilitate faster promotion of MAP species and address the bottlenecks, if any.
- Sri Lanka does not earn from oil or coal and, therefore, without confining to a few crops, there is urgent need to now focus on looking for more medicinal and aromatic plants of economic value.
- Sri Lanka is producing the world's best cinnamon and exporting around 75 per cent of the total world requirement. It is the right time to pay greater attention to quality of spices and products and concentrate more on developing products out of medicinal and aromatic plants instead of merely exporting raw materials for which appropriate strategies need to be developed.

Conclusion

In terms of the world market scenario, there is no option but to add value to Sri Lankan spices and gain recognition for the new products. In case of essential oils, there is a need to focus on business driven research and development in order to develop the essential oil industry. The prospects for these products are very bright because of the growing demand for the natural oils, organic products, oils for aromatherapy and substitutes for synthetic products.

Country Status Report on Medicinal and Aromatic Plants in Japan

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Introduction

Medicinal plants used to produce Eastern-style herbal (Kampo) medicine are defined by the Japanese Pharmacopoeia in Japan as crude drug materials. Currently, 248 items are listed. Kampo medicines are made from more than two kinds of crude drug materials, and prescribed by Eastern-style medical doctors. Kampo medicines have been traditionally used in Japan since ancient times. In general, medicinal effect of Kampo is mild, broad and with less side effects as compared to modern synthetic medicines. However, it is believed that long-term treatment by Kampo can change body constitution. They are still popular among Japanese society as alternative and complementary medicines. Annual production of Kampo medicine in 2007 was worth US$1,000 million (Japanese Kampo Medicine Manufacturers Association), and it is expected to double by 2015.

Aromatic plants are defined and regulated by 'the Food Hygiene Law' and 'the Food Labeling Guidelines' in Japan. Flavour and fragrance materials (FFM) are important for food, cosmetic and toiletries. Japan is a big importer of FFM, but the domestic production of natural FFM is very small.

Area, Production and Productivity

Annual industrial use of crude drugs in Japan is approximately 20,000 tons (2008). Since the Japanese domestic products are expensive and therefore 17,000 tons (83%) of crude drugs is imported from China. Share of domestically produced crude drug in Kampo medicine industry is only 2,500 tons (12%). However, due to recent economic growth of China, which is the big consumer of crude drugs, international prices of crude drugs are rising up quickly. Domestic production of these crude drugs is now becoming more important. Cultivation area of crude herbal drugs in Japan is 1,800 ha. It was about 2,500 ha until the middle of 1990's. After that, cultivated area in Japan decreased to about half in the middle of 2000. But, the cultivation area increased again in recent years. This is due to the fact that private companies producing Kampo medicine have specific contracts with local farmers or farmer cooperatives. In such drug farms, the variety, yield and quality are carefully controlled.

Total production of synthetic and natural flavour and fragrance materials (FFM) in Japan in 2009 was 129,000 tons (Japan Flavor and Fragrance Materials Association). Domestic production of FFM was 11,000 tons in 2009 and, FFM made from natural materials was only 620 tons (0.48%) Production of aromatic plants is very small in Japan, whereas Japan is the second largest FFM consuming country in the world. Main aromatic plants produced in Japan are lavender (11.7 ha, 78 tons) in Hokkaido, *Rosa rugosa* (0.1 ha) and geranium for which no data on cultivation area is available. The main crude drugs consumed in Japan are given in Table 1 and area and production of medicinal plants in different years are given in Table 2.

Table 1. Main crude drugs consumed in Japan.

Crude drug	Scientific name	Consumption (tons)	Domestic production (tons)
Kanzo	*Glycyrrhiza* spp.	1,267	0
Shakuyaku	*Paeonia lactiflora*	1,164	41
Keihi	*Cinnamomum verum*	1.034	0
Bukuryo	*Wolfiporia extensa*	996	0
Taiso	*Ziziphus jujuba*	676	0

Source: Japanese Kampo Medicine Manufacturers Association (2009)

Table 2. Production of medicinal plants in Japan.

Year	Number of farmers	Cultivation area (acres)	Production (tons)
1994	13,728	255,949	10,326
1995	12,873	262,284	15,947
1996	12,333	258,053	15,627
1997	11,446	191,277	9,841
1998	10,418	166,571	11,514
1999	8,863	165,547	12,432
2000	8,635	123,742	10,882
2001	6,806	106,128	9,556
2002	6,368	129,734	9,999
2003	5,981	123,546	12,587
2004	6,118	129,070	9,846
2005	6,098	118,794	6,137
2006	6,192	113,821	5,688
2007	6,290	114,293	7,931
2008	6,938	149,738	7,844
2009	6,372	183,896	9,311

Source: Japan Specialty Agriculture Products Association (2009)

Major Uses

The three main crude herbal drugs produced in japan are senkyu (*Conioselinum filicinum*), to-ki (*Angelica acutiloba*) and shakuyaku (*Paeonia lactiflora*). Aroma plants produced in Japan are lavender, geranium (pelargonium) and *Rosa rugosa*. These three species are mostly produced in Northern part of Japan.

Senkyu belongs to Apiaceae family. Its rhizome contains butylphtalide and other essential oils. These oils activate blood circulation. Senkyu is used to make Kampo medicines which are used to warm up body and enhance the metabolism. To-ki also belongs to Apiaceae family and is used to make Kampo medicines having a similar effect as senkyo. Major medicinal principle of to-ki is ligustilide which is an essential oil too. Shakuyaku (Paeoniaceae) contains several monoterpene glycosides such as paeoniflorin. Shakuyaku is used to prepare Kampo medicine which is used for making muscles relax, and helping blood vessels actions.

Another important crude drug is Kanzo (*Glycyrrhiza* spp.). Kanzo is a kind of slow growing plant and needs more than 5 years to be harvested as crude drug. It was produced and used in Japan, but now a days, almost 100 per cent of its requirement is met from imports from China. In 2009, price of locally produced kanjo products was US $ 50–70 /kg, whereas Chinese products costed only US $ 10-15 /kg.

The branch and inflorescence of senkyu, to-ki, shankuyaku are given in Fig. 1-3 and branch, inflorenscence, pod and root of kanjo are given in Fig. 4

Fig. 1. *Senkyu (http://www.westatic.com)*

Fig. 2. *To-ki (http://www.westatic.com)*

Fig. 3. *Shaku-yaku (http://www.westatic.com)*

Fig. 4. *Kanzo (http://chestofbooks.com)*

Significant Achievements

Germplasm collection, characterization conservation, and documentation

Research Center for Medicinal Plant Resources, National Institute of Biomedical Innovation in Japan (http://www.nibio.go.jp/english/index.html) is managing a collection of 4,000 species/lines of medicinal plants. NIAS Genebank, National Institute of Agrobiological Sciences (http://www.gene.affrc.go.jp/index_en.php) holds more than 250,000 accessions of plant resources including some medicinal plants. Universities and other national/public research institutions also maintain on various scales the genetic resource collections in Japan.

Variety development

Twenty patents related to variety development of medicinal plants were applied to Japanese Patent Office between 1971 and 1998. Most applicants were private companies producing Kampo medicines.

Cultivation practices

In Japan, medicinal plants are mainly cultivated at the contract farms according to an agreement between private companies and farmers or farmer groups. Seeds, seedlings, or plant stocks are provided by private companies with guidelines of cultivation. Instructors from private company visit the farms to check growth conditions continuously.

Senkyu and to-ki are propagated by division of rhizomes. Suitable season is late autumn. Rhizomes should be planted in shallow and soft soil to have a larger rhizome which is suitable to make crude medicine. These species prefer cold climate. Shakuyaku can be cultivated both by seeding and division methods. In seeding method, matured seeds are sown into wet soil at 2 cm depth. It is necessary to maintain soil moisture until germination. In case of live and grown-up plants, propagating by division is a better method.

Disease and pest management

Medicinal plants cultivated in Japan are likely to be affected by some fungal diseases. However, most antifungal chemicals are not allowed to be used at the medicinal plant farms. In Japan, pesticides to be used for agricultural production have to be registered in the Ministry of Agriculture, Forestry and Fisheries as per the requirement under the "Agricultural Chemicals Control Act". Currently, very limited number of chemicals are registered for use in medicinal plants.

Production of quality seed and planting material

The cultivation practices for production of quality seed and planting materials are the same as applied for growing the medicinal and aromatic plants in the field.

Primary processing, value addition and product development

They are done by suitable procedures to produce commercial products at the contract farms.

Marketing, commercialization and trade

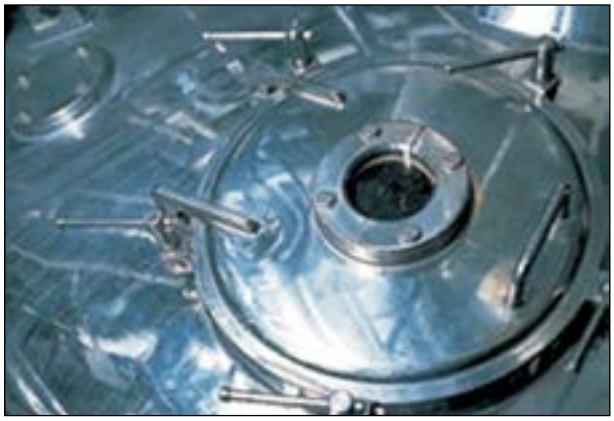
Private companies such as Tsumura and Co. (https://www.tsumura.co.jp/english/index.htm) developed many kinds of commercial Kampo medicine products. The crude drug materials are stored in temperature and humidity controlled stores and they are cut into proper size pieces with machines. The medicinal components are extracted in a large tank and the residues are removed by centrifugation. The medicinal components extracted are concentrated by spray driers. The entire process is controlled by optimized computer program. Quality checking is also done with the help of chromotographs. The different steps followed in Kempo medicine factory in Japan are depicted in Fig. 5.

Constraints and Opportunities

Kampo medicine industry in Japan is growing very fast, since the population of old people who are the main consumers of Kampo medicines is increasing. Kampo medicine industry in Japan is strongly depending on imported crude drugs, but recently the international prices of imported crude material started increasing. Government institutions and Industry-Government-Academia research groups started some research projects on efficient domestic production of important crude drugs, such as plant factory, plant biotechnology, and utilization of vacant plots in rural areas.

5(a) *Crude drugs stored in temperature and humidity controlled storages stores*

5(b) *Crude drugs cut into proper size with cutting machines*



5(c) *Medicinal components in crude drugs extracted in a large tank and residues are removed by centrifugation.*

5(d) *Medicinal components concentrated by spray driers.*

5(e) *The processes (a-d) controlled by optimized computer program*

5(f) *Quality checking with chromatographs*

Fig. 5. *Different steps in a Kampo medicine factory in Japan (Tsumura and Co.)*

Approaches for Meeting Emerging Challenges

Application of hydroponic culture technique in plant factory on medicinal plant production has recently been started to reduce production costs (land and labour) and to stabilize quality including the concentration of medicinal components.

Future Thrusts

The ageing of population in Japan is a very serious issue, since more than 20 per cent of the people are over the age of 65 years now and only about 25 per cent are in 20-30 years age group. Since the old generation is the main user of Kampo medicine, the market demands will keep on increasing for 2-3 decades in the future.

Conclusion

Crude drugs and flavour and fragrance materials (FFM) are important industrial materials, and there is a high demand for these in Japan. However, domestic production of MAP species in Japan keeps decreasing for the past 20 years, since most of the domestic products are much more expensive than imported materials from China and other Asian countries. Recently, adoption of some advanced techniques to produce MAP species in highly controlled fields or plant factories started to reduce the cost of production by improving production efficiency.

Country Status Report on Medicinal and Aromatic Plants in Malaysia

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Introduction

The Malaysian Government has acknowledged the herbal industry as one of the promising industry in the future. This industry is also very much interrelated with the development of agriculture, pharmaceuticals, life science, healthcare and food industry. Even the Third Agriculture Policy (NAP 3) has identified the herbal industry as a new source of wealth for Malaysia. Under the 9th Malaysia Plan (RMK 9), the Government is focused on developing the herbal product as a new segment targeted to spearhead the economic growth in the country.

Malaysia has a rich variety of underexploited plant species and about 1,200 of them have been known to have medicinal properties. However, insufficient supply of local raw material when required in large quantity has always been one of the major constraints in the local Malaysian herbal industry. The local industry relies heavily on materials either collected from the wild and/or imported from other producing countries such as Indonesia, India and China. This dependence on wild sources and/or imported raw materials has many disadvantages such as unreliable supply, materials of poor quality, unreliable identification and possibility of contamination and adulteration. Under such enormous challenges, there is a need to systematically cultivate herbal plants for large-scale commercial production. The best approach is by practicing modern agronomic cultivation methods and practical post-harvest handling technology during the upstream activities to ensure sustainable supply of quality raw materials for the industry.

Another important aspect in the herbal industry is the product development where the raw materials were processed into various value-added products during the downstream activities. However, for the herbal products to be legally approved by relevant authorities for use by the masses, the products must have scientific basis for efficacy and safety. Under traditional practices, testimonials were accepted as proof of efficacy but are not accepted under the current regulations. Under such situation, all herbal products to be considered as phyto-medicine must pass all requirements prior to being approved for use.

Efforts for Improving Local Herbal Industry

Realizing the stringent requirement for the local MAP species to penetrate global market, efforts were and are still strongly being pursued by the Government of Malaysia to ensure that the local products meet the regulations of the target countries. In 2010, economic transformation programme (ETP) has been initiated with several National Key Economic Areas (NKEA) and Entry Point Projects (EPP) to move the country's economy.

National key economic areas **(**NKEA) are at the core of the economic transformation program (ETP) and are defined as the drivers of economic activities that has the potential to directly and materially contribute a quantifiable amount of economic growth to the Malaysian economy that is measured through gross national income (GNI) and job opportunities created. The approach of NKEA differs from the normal approach where the private sector will lead the initiatives and the government becomes facilitator of the initiatives.

Table 1. Different sectors under NKEA

S. No.	NKEA sector	S. No.	NKEA sector
1.	Oil, gas and energy	7.	Wholesale and retailing
2.	Palm oil	8.	Education
3.	Financial services	9.	Health
4.	Tourism	10.	Communication and infrastructure
5.	Business services	11.	Agriculture
6.	Electronics and electrical	12.	Greater Kuala Lumpur/Klang valley

The focus of agriculture NKEA is on high growth potential sub-sectors such as aquaculture, seaweeds, bird nest and premium processed food. The efforts will enable Malaysia to enter high value global market. The aim of agriculture NKEA is to achieve high GNI from RM 28.9 million to RM 49.1 million in 2020. An estimated about 109,335 additional job opportunities are to be created during the period. To achieve the objective, 16 entry point projects and 11 business opportunities have been identified as catalyst for business development that is driven by market demand, industrial scale and having integrated agriculture activities utilizing modern technologies.

Under this initiative, the contribution from government agencies will also be recognized such as the Ministry of Agriculture and Agro-based Industry (MOA) to be one stop center for herbal industry and acts as the secretariat for Herbal Development Council (HDC) in EPP1 of which will be implemented by Crop, Livestock and Fishery sector (CLFS or ITTP) and Herbal Development Office (HDO).

EPP1 - Unlocking Value from Malaysia's Biodiversity through High-Value Herbal Products

MOA will explore the value from Malaysian biodiversity through production of high value herbal products in EPP1 (ETP, 2011). The focus is to increase product quality and market possibilities to penetrate global export market for nutraceutical products and phyto-medicine.

Rationale: Global demand for herbal products, which amounted to RM672 billion in 2006, is projected to triple by 2020 (Fig. 1). The shift in healthcare, denoted by global growth in nutraceuticals, towards a preference for natural products with therapeutic value provides opportunities for Malaysia to become a significant global player, given our rich biodiversity. However, the majority of local products are largely in the low-end market segment such as fortified beverages. Diversification towards high-end herbal products based on standardized extracts and validated by clinical studies remains weak due to lack of industry champions, weaknesses in local R&D, large investment required for clinical studies and difficulty in penetrating international markets.

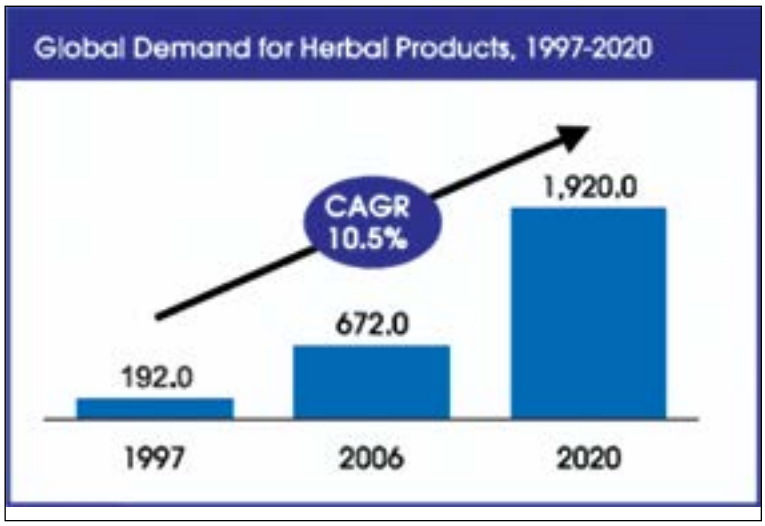


Fig. 1. *Global demand of herbal products*

(Source: ETP document, P. 514)

Actions: To address these issues and move up the value chain, six programs will be implemented under a coordinated national project. The aim is to strengthen product quality and marketing efforts to penetrate global export markets for nutraceutical products and botanical drugs. Several popular Malaysian MAP species have been identified as the focus, including *Tongkat Ali, Kacip Fatimah and Misai Kucing*.

Establishment of herbal centre of excellence: Each centre will respectively lead R&D in discovery, crop production and agronomy, standardization and product development and pre-clinical studies. The centers of excellence will be responsible for coordinating research amongst research institutions, establishing strategic research collaborations amongst domestic and international institutions, ensuring quality of research output and obtaining intellectual property rights on the research findings.

Promote and market a national brand: It is important to promote and market internationally a national brand as the identity of Malaysia's healing and beauty tradition. Local herbal products will be exported under the umbrella brand. Government will work with foreign regulators to facilitate the registration of Malaysian herbal products in their markets. This will reduce the need for individual companies to invest in branding and product registration.

Development of herbal cultivation parks: There is a need to develop herbal cultivation parks in Durian Mentangau and Pasir Raja in Terengganu, Cegar Perah in Pahang and in Rantau Manis, Kelantan. This is to ensure adequate and consistent supply of raw materials. The parks will undertake herb cultivation at commercial scale based on a contract-farming model. Each 400 hectares park will allocate 40 per cent of its land to be cultivated by more than 50 out-growers (Fig. 2). The out-growers will benefit in terms of technical skills development, production quality assurance, secure off-take and income from the anchor company. It is anticipated that out-growers will have the potential to earn RM 3,000 per month (Fig. 3).

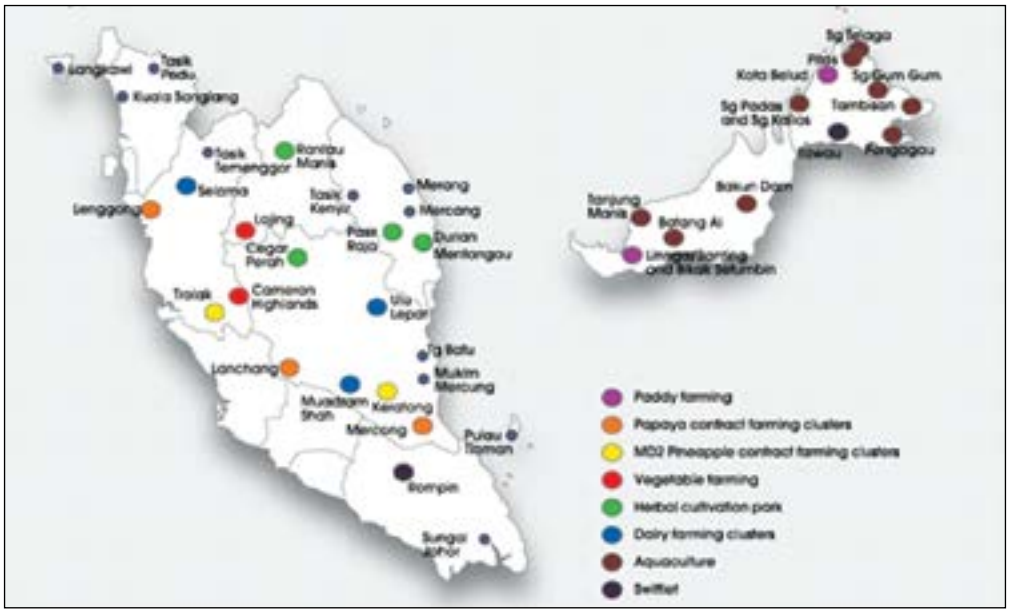


Fig. 2. *Target locations for EPPs distributed across the country*

(Source: ETP Document, P. 526)

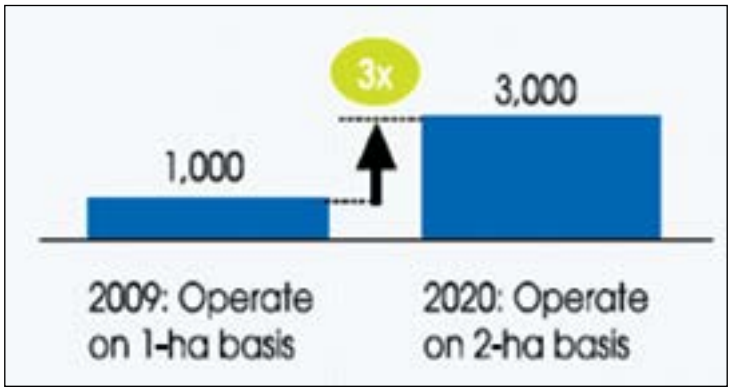


Fig. 3. *Average monthly income of herbal out-growers (RM/month)*

(Source: ETP Document, P. 521)

Expand extraction facilities: There are currently limited commercial-scale facilities; most are small or of pilot scale and not designed to operate commercially. New facilities will be built, each with a capacity of 1,000 kilograms per week to supply the industry with reliable, premium quality extracts at competitive cost.

Development of herbal clusters: Department of Agriculture (DOA) is developing the clusters with the aim of ensuring sufficient and consistent supply of herbal raw materials. Covering an area of 40 hectares with the involvement of 44 herbal growers / entrepreneurs in 2011. The production of MAP species from these clusters would fulfill the demand/supply of the raw materials sufficiently and consistently to the manufacturers and/or local entrepreneurs in Agriculture sub-sector of NKEA program for Herbal Project Sub-group and those involved in herbal processing industry under consistent supply of chain system management.

Enablers: The Malaysian Herbal Development Council will be set-up which will be responsible for the end-to-end development of the herbal industry, including setting strategic directions and developing appropriate policies and regulations for the benefit and growth of the industry. The council will consist of members from both Government and private sectors and will enable coordination across 24 government, state authorities and private sector bodies currently involved in this sector.

While the main EPP for herbal products focus on five popular MAP spices, two related business opportunities have been identified. There is potential to capture value from the development of other MAP. Funding will be provided to accelerate the commercialization of new products that are based on these MAP. Local manufacturers will be supported to move up the value chain through the provision of financial assistance, R&D support and marketing efforts. Other key agencies, companies and organizations involved in EPP1 are Department of Agriculture (DOA), Malaysian Agricultural Research and Development Institute (MARDI), Ministry of Health, Ministry of Natural Resources and Environment and Khazanah Nasional.

Additionally, the possibility of acquiring a foreign distributor with large distribution networks in strategic markets such as the US, EU or China will be studied and pursued. This is to assist in overseas market penetration of Malaysian herbal products.

Area, Production and Productivity

Total area and production for spices and MAP species has increased by more than 100 per cent over five years period from 2004 - 2008, from 2,485 ha to 5,265 ha for planted area and from 20,320 metric tons to 42,100 metric tons in production (Fig. 4). The increase in planted area and production indicates the positive trend of the industry.

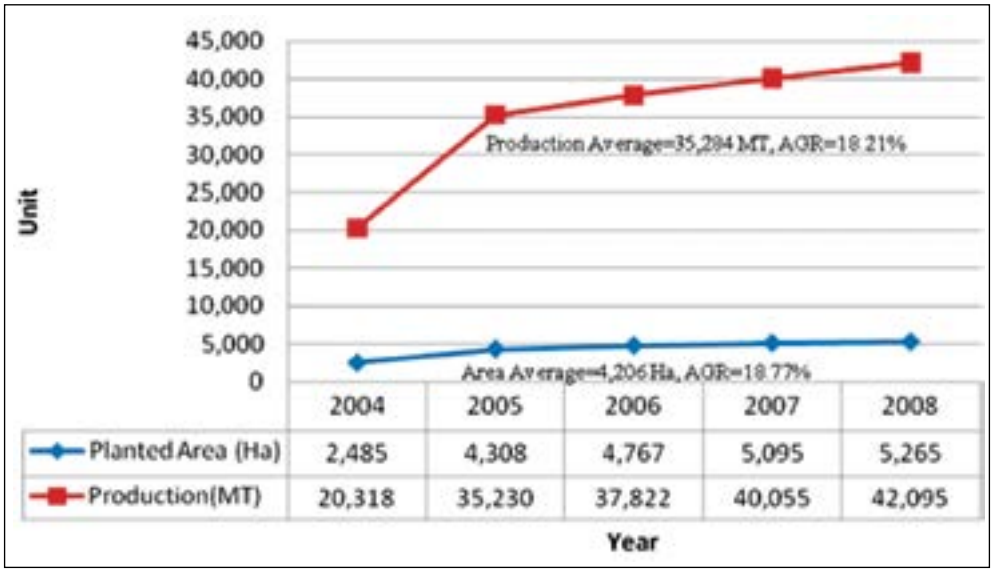
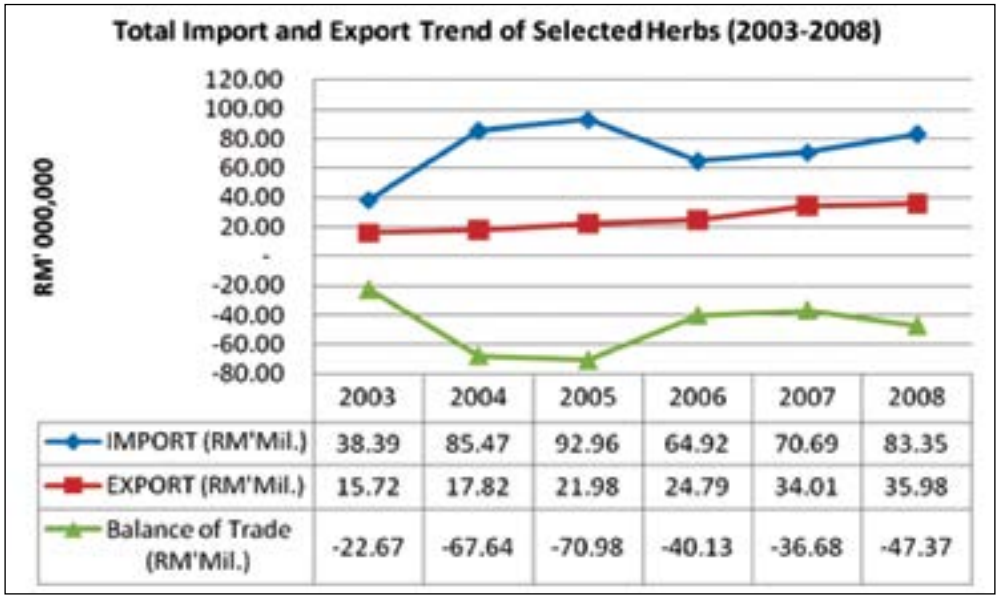


Fig. 4. *Total planted area (ha) and production (tons), 2004-2008.*

Source: Adapted from National Herbal Review (2009).

Figure below shows the trend of value of import and export of selected MAPs of Malaysia. In 2008, an export of MAP species products was valued at RM 35.98 million which increased from RM 15.7 million in 2003. Imports in 2008 amounted to RM RM 83.35 million from RM38.39 million in 2003. There was thus a net decrease of about RM 47.37 in 2008 of exports over imports (about 2.2 times more than in 2003).

The import value for 2008 growth trend increased by 15.5 per cent, while the export value (inclusive of re-export) trend growth by 16.7 per cent. The trend for balance of trade (BOT) was negative for the period from 2003 - 2008 (Fig. 5).



	2003	2004	2005	2006	2007	2008
IMPORT (RM'Mil.)	38.39	85.47	92.96	64.92	70.69	83.35
EXPORT (RM'Mil.)	15.72	17.82	21.98	24.79	34.01	35.98
Balance of Trade (RM'Mil.)	-22.67	-67.64	-70.98	-40.13	-36.68	-47.37

Fig. 5. *Growth of total import and export of herbs*

Source: Adapted from National Herbal Review (2009).

The average value of imports has exceeded the average value of exports. This shows that the value (hence volume) of the raw material utilized by the domestic herbal industry are huge and they come from outside sources especially China, India and Indonesia of which mostly imported by the Chinese, Malay and Indian traditional medicine traders.

Number of entrepreneurs involved in planting MAP is very small. In 2009, only about 11.8 per cent of the entrepreneurs planted MAP to obtain the supply for their own requirement as well as producing the raw materials for other manufacturers. Majority of the entrepreneurs (88.2%) did not plant any MAP but got their supply of raw materials from these producers or from imports. The areas planted with MAP by the entrepreneurs are still small, mostly less than one hectare. Most of these planters fall into the smallholder category. However, current developments may attract higher number of growers/producers to get involved in cultivation of MAP.

Major Uses

The MAP species in priority list of EPP1, and their scientific names and uses are given in Table 2.

Table 2. Priority list of MAP species in EPP1

S. No.	Local name	Scientific name	Uses
1.	Tongkat ali	*Eurycoma longifolia*	Vitality, anti-cancer, anti-malaria, anti-HIV
2.	Kacip fatimah	*Labisia pumila*	Induce and facilitate childbirth, post-partum medicine, flatulence, dysentery, dysmenorrhoea and gonorhoea, 'sickness in the bones' and haemorrhoids
3.	Misai kucing	*Orthosiphon stamineus*	Diuretics, hypertension, diabetes, anti-inflammatory, anti hyperuricemia and gout, antilithiasis, antioxidant, hepatoprotective, antifungal, antiobesity,
4.	Hempedu bumi	*Angdrgraphis paniculata*	Anti-inflammatory, anti*bacteria,* antivirus, fever, analgesic, expectorant, deworming
5.	Dukung anak	*Phyllanthus niruri*	Diarrhoea, gout, kidney ailments, urological disorders
6.	Halia	*Zingiber officinale*	Sinusitis, stomach upset
7.	Pegaga	*Centella asiatica*	Post-natal medication, ulcers, wounds
8.	Mengkudu	*Morinda citrifolia*	Dysentery, flatulence, malaria
9.	Mas cotek	*Ficus detoidea*	Blood pressure, diabetes
10.	Roselle	*Hibiscus sabdariffa*	Diuretic, anticancer, antispasmodic, antibacterial, febrifungal, hypotensive, high blood pressure and promote peristalsys.

Significant Achievements

Germplasm collection, characterization, conservation and documentation

Continuous efforts are being made by MARDI to collect, characterize, evaluate and conserve the germplasm including MAP species. A National Genebank was recently been established and MARDI has been tasked to manage the genebank. Currently, there are more than 400 species of MAP held in the collection. For *Ficus deltoidea*, 42 accessions were collected and characterized. Some of the accessions have been evaluated and a few accessions were found to contain biochemical contents such as saponin, naringin and moretinol that may contribute to development of phytomedicines.

Variety development

Efforts are continuously being made towards development of varieties in MAP, though on a limited scale, under the project at MARDI and new pegaga accessions have been developed through a breeding program.

Cultivation practices

MARDI has successfully developed and published cultivation practices for about 20 popular local MAP species. The technology serves as guidelines for the growers/producers to cultivate their own MAP species and ensuring optimum yield of high quality raw materials.

Disease and pest management

Recent work on dukung anak has identified important diseases and pests for the species. The degree of infestation and severity of the disease had been established. Control method using bio-pesticides had also been developed. The work on pests of tongkat ali has identified tiger moth as the most important pest that can severely affect the plant growth.

Production of quality seed and planting material

The production technology for herbal cultivation includes production of quality seeds and planting materials. Prior to planting, the planting material, be it seeds or vegetative cutting, must go through intensive selection process to ensure that only healthy planting material is transferred to the field for successful cultivation.

Primary processing, value addition and product development

R&D activities on several essential oil plants had also been understood. Essential oil had been extracted from plants such as patchouli, lemon grass, citronella and cajuput. The essential oils were then utilized to produce value-added health related products such as shampoo, bath gel, soaps and also for use in aromatherapy.

Marketing, commercialization and trade

Since MARDI is a R&D organization, its involvement in marketing, commercialization and trade of herbal products is limited to training of the entrepreneurs under incubator-incubatee program. The incubatee will use our facilities for training in specific area such as production of essential oil based products. Upon graduation, they are entitled to use the technology to produce their own products and commercialize them.

Constraints and Opportunities

Traditional medicine: Although the traditional medicines have gained recognition from the Government by setting up the traditional and alternative medicine clinics at several Government hospitals, it has not gone outside the country. This is due to limited studies and scientific basis of the usage/claims. However, the current efforts in Malaysia have opened up the possibilities for export of traditional medicines based on proper efficacy, toxicology and safety tests of the products.

Modern medicine: The knowledge in modern medicine will always be used as guidance for the traditional medicine especially with the current trend of health conscious consumers that are going back to traditional medicine with various reasons. Modern medicine uses single compound as medicine and the basic compound is obtained from plant source. If the active compound in plants can be extracted as single compound, then there are possibilities for enhancing the value of herbal plants to produce the pharmaceutical drugs. However, appropriate studies must be properly done to ensure efficacy and safety of a particular drug from plant origin.

Approaches for Meeting Emerging Challenges

Various issues and challenges related to the local herbal industry need to be overcome to develop the industry. These resources include availability of land for planting MAP, manpower to operate and manage the farm, financial support, infrastructure, machineries, input, planting materials plus technology and knowledge for planting and handling of MAP (Herbal Review, 2009). Earlier in 2006, another researcher has also indicated that resources such as finance, workers, technology, raw materials and marketing were the five most important underlying factors hampering the growth and development of the herbal industry in Malaysia.

Land availability for planting MAP

Several types of land is available for planting MAP such as small pockets of idle land, large plantations, forest reserves and timber concession areas. However, several issues must be resolved before these lands are available for planting of MAP. The issues include status and land ownership, remoteness and accessibility of the land. It is not easy to solve all these problems and if they can be solved it may take many years before the land can be utilized. The total estimated area of land planted with MAP was about 3,281 ha in 2008 which was more than 100 per cent of the area planted with MAP in 2002 of 1,495 ha. The Government of some states have designated some areas of land for agriculture development such as in the economic development corridors in East Coast Economic Region (ECER). The Terengganu State Government had allocated about 1,000 ha for MAP cultivation.

Work force for farm operations

Another main constraint for development of local herbal industry is the availability of work force for farm operation and maintenance. Previous report had indicated about 45 per cent of the farm operators are above 50 years old and only 30 per cent of the younger generation are willing to work on farms. However, the sustainability of the young work force is a big issue due to lack of incentives for them to continue working on the farm. There is lack of opportunities for career development and the prospects for better wages in agriculture sector are not attractive enough to maintain the young work force to stay on the farm. Engaging foreign labour also poses some problem because of the high wages and the legal procedures which they have to abide as per the immigration rules and regulations. The availability of these labours may also be short lived as many will eventually leave the farm for better opportunities in other sectors such as manufacturing or construction. The fast turnover of these workers is putting a lot of pressure on the farming sector due to time and money spent in training them to work. This is still a continuous problem faced by the local agriculture sector.

Financial assistance

It is not easy to obtain loan from financial institutions for farming activities. Most banks are reluctant to provide loans as farming is considered as a very risky business venture. This is the main dilemma facing the entrepreneurs who want to start a farming business. However, under the current set-up, loans from Agrobank may be available for some agriculture industry. Even though some form of assistance is provided in the form of land lease, infrastructures and utilities under the herbal cultivation parks and clusters in EPP1, but direct financial assistance

for operating cost is not provided for. The best solution is to establish a special fund as loan to meet operating cost in herb production, which can be managed through HDC of Ministry of Agriculture.

Equipment and machineries

Normally, size of farm determines the farm equipments and machineries. Larger farms especially those that are managed by the plantation sector such as Federal Land Development Authority (FELDA) normally have adequate farm infrastructure, equipments and machinery for their cultivation activities. Small farms still depend upon rented equipments and machineries while most operators do not have adequate post-harvest handling facilities. Activities such as washing, drying, grinding and packaging were mostly done manually. Even large farms are not keen to invest in procurement of post-harvest equipments because they are not sure of the return from their investment. While it was possible to fabricate and modify equipment to suit local requirement, many operators were reluctant to do so because the venture is not economically viable due to the small volume of MAP to be processed. This situation can be overcome if the Government takes the initiatives to build central collection and processing centres to promote proper handling and management of the MAP. The establishment of such center equipped with up-to-date post-harvest equipments will ensure the herb quality after harvest.

Infrastructure for herbal production

Overall, there is sufficient basic infrastructure such as roads, electricity and water supplies to support the development of local herbal industry. However, lack of marketing coordination between the growers/producers and the processors/manufacturers may hinder the success of this industry. Incidences of oversupply and undersupply of raw herbal materials has occurred in the past that have resulted in dumping of local raw materials and the importation of raw materials from neighboring countries. In some instances, growers/producers cannot sell their MAP raw material because the volume is too small for the processors and the manufacturers will not buy the raw material because the amount is insufficient for processing. Under the current set-up, such problem will cease to occur as the HDC/HDO will coordinate the planting and supply of MAP material from growers/producers to processors/manufacturers.

The setting up a collection, grading and handling center in herbal clusters and herbal cultivation parks can help to solve the above problems. This pack house can act as trading house for operation of handling activities such as grading, storage and distribution of local MAP material. The trading house at the same time can also act as the intermediary between the producers and the manufacturers. They can buy, sell and store sufficient amount of MAP based on the requirement of the manufacturers. The Government through EPP1 has provided assistance to establish these packing houses and opens opportunities for development of downstream processing facility for local herbal industry.

Inputs for herbal industry

Inputs such as fertilizers and agro-chemicals should be easily available for herbal industry. The agriculture and chemical industries in Malaysia are well developed to support the production

of herbal raw materials. However, issues of high cost of fertilizers and agro-chemicals (both organic and inorganic) need to be addressed as this will lead to high cost of production which will be detrimental to the local herbal industry and can make it uncompetitive globally.

Technology and knowhow in cultivation and handling of MAP

Technologies for production, primary processing and post-harvest handling are still inadequate for the local herbal industry. The present knowhow for crop production and management is insufficient to meet the present and future demand for good quality raw materials required by the industry. Currently, available technologies are highly labour intensive, which may result in high cost of production and reduced competitiveness in the market. There is also lack of specific production system for herbal cultivation and technology database for herb production is still insufficient. Even though many of the research institutions such as MARDI, Forest Research Institute of Malaysia (FRIM) and universities had been working hard to produce and develop appropriate technologies for the production and post-harvest handling activities, a lot more work is required to generate and disseminate the new technologies to the end users in the industry. Another important area of research that requires special attention is the domestication of herbal materials collected from the wild. As the local herbal industry still relies heavily on raw materials collected from the wild or from imports, domestication offers possibilities of making the supply of MAP readily available for the industry. At the same time, the depletion or extinction of the species can be avoided and imported MAP species can be substituted with locally cultivated herbal raw materials.

Supporting industries

Apart from the strong presence of key components of herbal industry e.g. raw material supply, processing/manufacturing, marketing and distribution, supporting industries are also vital in ensuring competitiveness and sustainability along the value chain of the local herbal industry. Packaging, production design and machinery importers/ design fabricators are also key factors in the development of herbal industry. Production of planting material can be a new sub-sector and although the number is small, current players are either raw material producers themselves or other nurseries extending their reach to herbal industry. Research and development is another vital area for the sustainability and growth of the herbal industry. Although local research institutes and universities are active in undertaking R&D in herbal sector, translating the research results into viable products and services, particularly in pharmacy and medicines, remains an issue and the economic benefit is yet to be seen.

Marketing and distribution system

Malaysian herbal products need to have an edge over imported herbal products, some of which are cheaper than products developed in Malaysia. The consumer perception of local products is still low, as the consumer mind set for Malaysian product generally relates it to low in quality and less attractive as compared to imported goods. In general, imported products have more attractive packaging and marketing with a more effective distribution system, savvy and attractive advertisements and certifications to promote their products. Consumers today are more discerning with their purchases and most of the time they would buy the products of brands or trademarks that are familiar to them as they associate familiarity to

product quality and reliability. Local manufacturers and companies are still lacking in terms of emphasizing the development of brands and trademarks to create unique identity and niche market. As a result of this, Malaysian products are becoming less popular as compared to imported product, which in turn resulted in the local product to be unsuccessful in the local and international markets.

Future Thrusts

Malaysia is in the midst of progressive move and efforts are being made to systematically develop the local herbal industry from the traditional way to scientifically proven way of utilizing the local MAP species. The needed thrusts for the local herbal industry include: i) production of quality seed/planting materials, cultivation of selected MAP by utilizing modern farming practices to maximize quality production including post-harvest management; ii) turn the raw material into intermediate products to maximize the yield and quality semi-processed materials, iii) enhance the value of products through standardization and processing using advanced technologies, (iv) enforce related regulation to ensure sustainable production of herbal raw materials together with the plan to avoid local MAP species from being extinct.

The establishment of Herbal Development Office under National Herbal Council should steer this industry into greater height with the aim of making the local herbal products acceptable internationally with sufficient scientific basis of their efficacy and safety.

Conclusion

The herbal industry in Malaysia must move forward progressively as it continues to receive strong support from the Government in the Economic Transformation Program through agriculture sub-sector of NKEA. Various committees, clusters, cultivation parks have been established/formed in EPP1 to drive the efforts to make this industry successful with cooperation and collaboration from private sector, Government agencies, research institutions and universities.

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Country Status Report on Medicinal and Aromatic Plants in Papua New Guinea

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Introduction

Lying just south of the equator, 160 km north of Australia, Papua New Guinea (PNG) is part of an arc of mountains stretching from Asia, through Indonesia into the South Pacific (Mittermeier *et al.*, 1977). PNG is the world's largest and highest tropical island (Mittermeier *et al.,* 1977). The country is richly diversified in languages, culture, customs, traditions, native flora and fauna (Beehler, 1993). It is one of the 'last frontiers' which truly defines richness of diversity. Geologically, PNG has the highly mountainous, arid to rain forest, coastal swamps to alpine forest areas (Beehler, 1993).

The country consists of more than 600 islands, the lowlands (0-1200 m) and highlands (1200-2800 m). As many as 800 ethnic groups exist, and 800-850 distinct languages are spoken in the country (Beehler, 1993; Loh and Harmon, 2005). It is known that close geographical relationship between areas of high biological and language diversity exists and that particular cultural practices and linguistic traditions are compatible with high biodiversity (5th National Report PNG, 2010).

PNG is the 4th mega-biodiverse country in the world (Swartzendruber, 1993). It has 70 per cent of its land covered by tropical rainforest. It covers less than 1 per cent world land mass but contains more than 5 per cent of biodiversity (WWF, 2007). The total number of plants and animal species exceeds 200, 000 (John, 1993). Scientists estimate that more than half of the plants and animals found in PNG have yet to be named scientifically. Fortunately, much of this biodiversity has remained intact for thousands of years because of the ruggedness of the terrain that made the interior lands inaccessible. Coupled with low population density, it also ensured that this biodiversity was never overexploited.

With more than 30 million hectares of closed tropical forests, PNG ranks 9th among the most forested tropical countries of the world (John, 1993 and Shearman *et al.,* 2008) Though estimates of total world species vary dramatically, it is estimated that 15,000 - 20,000 species of vascular plants may be found in PNG. Of these, perhaps 60 per cent are endemic to PNG, one of the highest rates of endemism in the world (Shearman *et al.*, 2009).

PNG is a culturally diverse nation consisting of hundreds of distinct tribes. The lives of most of these tribal groups are intimately linked to their environment. They still survive through

subsistence farming, food gathering and hunting. Their food, housing, clothing and ritual materials are still largely obtained from their immediate surroundings. This extended habitation of diverse environments by various tribal groups has led to an especially rich tradition of medicinal plant use in PNG with well over 50 per cent of the population relying exclusively on medicinal plants for healthcare (Rai, 2004). The decline of the environment threatens the way of life for many of PNG's tribes.

Medicinal and aromatic plants are produced and offered in a wide variety of products, from crude materials to processed and packaged products like pharmaceuticals, herbal remedies, teas, spirits, cosmetics, sweets, dietary supplements, varnishes and insecticides. Global market for MAP has been growing at seven per cent annually, capitalizing on the growing awareness of herbal and aromatic plants worldwide (Newman and Cragg, 2007). A World Bank commentary has observed that "while commercial cultivation of medicinal plants is taking place on a miniscule scale, this activity is poised for 'dramatic growth' in the coming decade and favours organic and mixed cropping to ensure 'good agricultural practices' (Zhang, 2003). Importance of MAP becomes even more critical when we look at the intricate relationship that exists between biodiversity, ecosystem and human health. Nature remains the mainstay of medicines today as half or more of the prescribed medicines come from the natural sources, directly or indirectly. This further emphasizes the need to preserve, protect and develop PNG's abundant natural resources for economic and health benefit of the population. The question that needs to be addressed is whether MAP could be developed on a sustainable commercial scale for the benefit of all those involved.

Area, Production, and Productivity

The data on area, production, yield and variety development of MAP in PNG is lacking. It is quite obvious that cultivation of MAP is quite small and limited to small family gardens. Most species grow naturally in primary and secondary forests and coastal areas all over the country, and are not exploited for commercial or trade purposes. Many aromatic plants such as mentha and lemon grass and others can be grown successfully on a bigger scale provided there was identified market and provision of incentives for the farmers. Impetus in terms of planning, funding, production, processing, and strong market linkage is essential to harness the potentials of commercial production of MAP in PNG.

Medicinal and Aromatic Plants and Their Uses

There are an estimated 400 types of essential oils traded in the world with US $ 5 billion in value. Global trade for flowers and fragrances were worth US $ 22 billion in 2010 (MNS-ITC Report, 2011). However, there are no commercial or large scale plantings of medical and aromatic plants in PNG, and there is very little marketing and trade of these materials. Small scale production of essential oils is limited to domestic markets only. There are hundreds of plant species that are used by indigenous people for sickness and physical ailments, but these plants are not commercialized. They are used mostly by rural people.

A number of plants have commercial potential but government policy and finance is needed to develop an essential oil industry. Although essential oils are not currently produced at commercial scale, an estimated 30 aromatic plant species have been identified for potential development and industrial application in PNG. Some of these are mentioned below:

Cryptocarya masoy (Massoia bark): The bark and hardwood contains C-10 lactone, golden coloured oil. An experimental pilot plant has been set-up in Central Province of PNG to investigate and explore commercial potential of the oil. Massoia lactone has an odour that is described as sweet, coconut meat, creamy, milky and waxy (Rali, 2013).

Asteromyrtus symphyocarpa (Waria-waria tree): Wari wari oil is obtained from Waria-waria trees that grow prolifically in PNG's Western province (Rali, 2013 and John, 2013). It's a type of melaleuca, and its leaves contain oil with basically the same medicinal qualities as eucalyptus oil. The Australia's Commonwealth Scientific Industrial Research Organization (CSIRO) and Australia Tree Seed Centre (ATSC) in partnership with the PNG National Forest Authority and the PNG Biological Foundation have established a sustainable essential oil industry in Western Province. The oil is used to treat cough, pains and infections but other claims have also been made about the uses of benefits of the oil locally including solving baldness and curing malaria, etc. but basically the oil is cineole rich like medicinal eucalyptus oil and has very similar uses (Womersley, 1995). There are five distillation stills in three villages, but a viable industry is yet to be developed. The waria-waria oil is already popular in the Port Moresby markets, but it is hoped that eventually the oil can find a wider market and create a viable local industry.

Santalum macgregorii (Papua sandalwood): Due to its wide use, this tree is overexploited and considered a threatened species (Womersley, 1995). However, measures have been recently introduced for sustainable harvesting and conservation of this tree. Sandalwood oil is a pale yellow liquid and used as general fixative in almost any perfume type.

Pogostemon cablin (Patchouli; also called patchouly or pachouli) is a species of plant from the genus *Pogostemon* (Womersley, 1995). It is a bushy herb of the mint family, with erect stems, reaching two to three feet in height and bearing small, pale pink-white flowers. The heavy and strong scent of patchouli has been used for centuries in perfumes, and more recently in incense, insect repellents, and alternative medicines.

Aquilaria agallocha (Agarwood): The tree grows on high altitude. Agarwood is a resinous wood that occurs in tree *Aquilaria agallocha;* the resin produced is rich dark in colour (Womersley, 1995).

Elettaria cardamomum (Cardamom oil): The plant was introduced in highlands of PNG in 1960s. It is cultivated in high altitude mountainous region of highlands. Small communities are engaged in organic farming of cardamom as part of small enterprise that generates some income for the people (Womersley, 1995).

Tagetes genus (52 spp.): Essential oil known as tagette for the perfume industry is produced from some of the species. A number of these species abound in PNG (Womersley, 1995).

Morinda citrifolia (Noni): Noni juice and oil are produced from the fruits and root subtracts and sold in local markets. There are some large noni farms in the country that supply raw materials to these producers (WHO, 2009).

Zingiber officinale and *Curcuma longa* (Ginger and Turmeric): Ginger and turmeric belong to the family Zingiberaceae and are grown widely throughout PNG. In both plants, the underground stem (rhizome) is the commercial product. There are several pharmacological applications for these species. Both these plants are used in traditional medicines for their medicinal properties (WHO, 2009).

Other plant species: The other import plant species include: *Polygala paniculata* (Indian snake-root), *Euodia* spp., *Cymbopogon citratus* (lemon grass), *Piper aduncum*, *Piper gibblimbum*, *Alipina* spp., *Melaleuca leucadendron*, *Eucalyptus* spp., and *Plantifolia vanilla* (Vanilla) (Womersley, 1995).

Major Achievements

Germplasm collection, characterization, evaluation and conservation

Papua New Guinea joined the International Bureau of Plant Genetic Resources (IBPGR) South East Asian Regional Program on Plant Genetic Resources, two years after its inception in 1976. The main objective of this initiative was to promote and enhance the conservation and management of the region's rich and diverse plant genetic resources through collaborative activities that are of benefit to member countries. This initiative enabled the member countries to exchange useful genetic materials and information on plant genetic resources (PGR) utilization for the wellbeing of the people in the region. Under the IBPGR umbrella, number of several regional collections on plant genetic resources were established. The main focus of PGR work, however, remained on food crops and not much attention was given to MAP species (Kambuou, 1996).

The urgent national need at the moment is to collect as much as possible the indigenous medicinal plant resources and assemble them in *ex situ* collections, either as seeds in cold storage facilities or as living collections in field genebanks. There is a need to identify taxonomically these resources and characterize them accordingly. Since 2004, a good deal of this work has been carried out in the Traditional Medicine Database Unit based at University of Papua New Guinea in collaboration with Biological Sciences Herbarium of the University. It is felt that before these resources are utilized, they have to be properly evaluated and tested for their medicinal properties. Therefore, various researches are underway to evaluate medicinal properties of important medicinal plants. There is also a felt need for collaboration between PNG Government agencies such National Department of Health, Department of Environment and Conservation, and Department of Agriculture and Livestock on the conservation, evaluation, documentation and utilization of these medicinal plant resources.

Interest and support for the conservation and development of medicinal plants is increasing in all parts of the world including PNG. This is due, in part, to a growing recognition given to the role of medicinal plants in the provision of culturally relevant and affordable healthcare, in creating sustainable livelihoods and in the vital conservation of biodiversity. This has also drawn the attention of the world community towards the need for creating mechanisms to ensure sustained development of the sector and to allow sharing of information between countries, organizations and agencies. Although plants are widely used in the traditional systems of medicine in PNG it is only recently that some interest is being shown by the private sector and NGOs in this area (Rai, 2012).

Requirement for diverse genotypes of medicinal and aromatic plants that give higher yield of specific compounds used in medicine will never cease in developing new varieties (Rai, 2012). Unfortunately no work is going on in PNG in the area of germplasm collection, characterization, evaluation, etc. However, the need and importance of variety development for work in future cannot be underestimated. Also, very little effort has been made in variety development, and cultivation of medicinal and aromatic plants. None of the important plants are cultivated for

processing or product development or export and commercial development. There is also no Government policy in place for promotion and commercial development of medicinal and aromatic plants at present.

Since the incorporation of National Policy on Traditional Medicine in 2007 (National Department of Health, 2007), systematic survey and documentation of medicinal plants has been undertaken and still continuing.

Variety development

Variety development work on medicinal and aromatic plants in Papua New Guinea is lacking. No efforts seem to have been made towards development of high yielding and disease and pest resistant varieties through breeding approaches in medicinal and aromatic plants.

Disease and pest management

Village-based agriculture supports between 70-80 per cent of the PNG population with domestic trading of fresh produce which is a very important source of cash income. Crop protection is vital to sustain this sector. Several projects supported by Australian Centre for International Agricultural Research (ACIAR) are looking at protection of food crops from pests and diseases in PNG. Scientists at the Cocoa Coconut Institute of Papua New Guinea (CCI) have developed a series of low, medium and high-input options (involving pruning, pest and disease control, shade tree management and resistant varieties), which form the basis of integrated management strategies to reduce yield losses from pests and diseases in the cocoa crop. Similar efforts will be needed to protect MAP species once some of these are brought under cultivation.

Production of quality seed and planting material

PNG has a huge oil palm agricultural industry. Selection of palms for seed production relies on strict selection criteria, based on progeny testing results as well as family and individual phenotypes. Seed production procedures focus on achieving high productivity from selected palms to maintain high selection intensity. Blank pollinations and other stringent quality control guarantee extremely high levels of seed purity.

Constraints and Opportunities

PNG health system is built on modern western medicine, though traditional medicine is widely used both in urban and rural areas. There is need to develop herbal industry in PNG to meet the potential demands in global and domestic market. The necessary growth drivers for development of herbal industry are health concerns, side effects of conventional drugs, higher confidence, cultural acceptability, and competitive pricing. In the past two decades, there has been increasing appreciation toward maintaining health with natural products vs. curing disease with chemical drugs. There is also growing awareness of side effects of synthetic drugs. In recent years, consumers are showing greater confidence in scientifically validated and quality products of traditional medicines. Besides, herbal extracts and powders are comparatively cheaper than synthetic drugs and formulations (WHO, 2012; National Health Plan, 2012). The major constraint is lack of national planning and strategies to develop MAP sector.

Overview of Health Sector

PNG has 21 provinces and the National Capital District in four administrative regions. There are altogether 89 districts in the country. Health delivery is mainly provided at government and church health facilities. The Central Government is responsible for the national referral hospital, one speciality Hospital, 4 regional and 16 provincial public hospitals. The majority of health service delivery is carried out by provincial and local Governments in rural health services, including rural hospitals, health centres, health sub-centres, and aid posts. All of these services offer a mix of public health and primary and community care. Access to western healthcare for majority of the population is limited to Aid Posts or Community Health Centers that chronically lack staff and medicines (Govt of PNG, 2012).

The PNG's population is estimated to be 7.0 million, with a national growth rate of 2.8 per cent during 2000-2011. With the current trend of population increase, it is expected to reach 13 million by 2030, and to almost double again by 2050. PNG languishes in social disadvantage and disparity. The most recent estimates of mortality show some improvement, and life expectancy at birth continues to rise. Maternal deaths are very high, especially in rural areas. Infants have twice the chance of dying before their first birthday in rural areas as compared to urban areas. The evidence shows that health services remain poor and increasingly inaccessible. There are also new and emerging health threats that may further compound the problem of the current system.

Geographical location and access to modern health services

The majority (87%) of PNG's population live in rural settings. The National Health Plan 2011-2020 emphasizes strengthening primary healthcare services delivery for the rural majority and urban poor. A lack of clean water and poor sanitation facilities lead to gastro-intestinal illness, among the five most frequent illnesses (malaria, pneumonia, TB, skin infections and gastrointestinal diseases) in PNG. Nearly a third of all aid posts are closed. Child mortality in rural populations is double as compared to urban children. Diarrhoeal disease and acute respiratory infections occur with higher incidence. With population expected to double in the next twenty years, there will be substantial increase in demand upon health and other services.

Health indicators and concerns

PNG is classified as a lower middle income country; it has a growing economy that is built on its natural resources. The indicators of health status, however, show PNG as seriously disadvantaged across a number of measures of health. Several of PNG's health indicators are the lowest performing in the Pacific. Life expectancy is 15 years shorter and maternal mortality 3.5 times higher in PNG than in Fiji. Infectious disease and maternal and child health concerns account for the greatest burden of disease in the community, and typically the greatest burden on the health services.

Health of children similarly remains of concern. One child in every 13 born in PNG will die before the age of five years, a rate far greater than in any other country of the Pacific region. Malaria remains an intractable problem in PNG, and is the second most common cause of admission to hospital. It affects all age groups, but is most lethal in children, and with serious

consequences in pregnancy. There are some signs of hope, since there is an active malaria program in place and the incidence of malaria has steadily declined in the past ten years. Malaria and acute respiratory tract infections (in particular, pneumonia), are the two leading diseases in PNG. Tuberculosis is again of increasing concern. The past decade has seen the rapid dissemination of HIV throughout the country, reaching into every province and both urban and rural areas.

Medicinal Plants and Traditional Medicine Practices in PNG

Traditional medicine is an important part of the health system in PNG. The Government of PNG adopted the National Policy on Traditional Medicine in 2007. The policy aims to improve the quality and delivery of traditional medicine and its practices and identifies ways of integrating traditional medicine into the country's primary healthcare system. Traditional healers are permitted to practice at village and district level. Indeed traditional healers and medicinal plants have become important health resources in rural areas, particularly where aid posts and health centres are closed. The use of traditional medicine is very much part of the lives of local communities throughout the country. Each ethnic group has a long tradition of using plants and other natural materials for treating illnesses. Although no official data exists it is estimated that traditional medicine accounts for almost half of all healthcare delivered in the country. It is the only form of healthcare available in some remote parts of the country (Ambihaipahar and Rai, 2004). The knowledge of traditional medicine is passed on from many generations verbally, and mostly to family members. Some traditional medicine practices are unique and of cultural significance. There is now a concerted effort to document and safeguard the traditional knowledge of medicinal plant usage as it is national heritage. In some areas, the traditional medical knowledge is still kept secret and cannot be released or shared easily. In general, there is good awareness but there is also a strong perception that traditional medicine is not being utilized to its full potential.

Currently, medicinal plant preparations are used to treat various ailments such as sexually transmitted diseases, asthma, diarrhoea/ dysentery, body/abdominal pain, headache, boils/sores, tuberculosis, cold/cough, fever/ malaria and insect bites. According to 1999 national report, 80 per cent of the population in PNG are using herbal medicines and traditional medicine therapies. For people living in the most remote parts of PNG, distance from public health services often means that a traditional healer is the only option (Rai and Maibani, 2012).

There is acceptance of traditional medicine by doctors trained in conventional medicine, and traditional healers do not object to their patients also seeking conventional medical treatment (Rai, 2011). This mutual tolerance and acceptance contributes to the majority of the population utilising both forms of treatment. Despite the diversity of ethnic groups in PNG, there are several common concepts and beliefs around health and illness, including a universal belief in the power of sorcery, belief in the importance of adherence to customary law, and belief in the healing power of herbs and incantation. It should be noted that the national policy on traditional medicine explicitly excludes the use of sorcery.

Traditional medicine healthcare initiatives

Although the Department of Health in PNG has recognised traditional medicine as a valuable health resource, little has been done with the practitioners at the community level whose

services are patronized by seemingly large number of people. As part of the traditional medicine program of the National Department of Health (NDoH), a series of activities directed at incorporating traditional medicine in the national health system have been initiated in the past 10-12 years. These include systematic survey of medicinal plants and traditional medicine practices, establishment of medicinal plants database, training of traditional healers in primary healthcare, traditional healers register and network, research on medicinal plants and development of national herbal formulary (Rai, 2004; 2008).

A national office for traditional medicine within the NDoH and the Traditional Medicines Task Force were established in 1999. NDoH officially endorsed medicinal plant use in 2005 through the announcement of a Traditional Medicines Healthcare Initiative. The Task Force is now charged with promoting the National Policy on Traditional Medicine (2007) nationwide, selecting 'safe and effective' traditional medicines, developing a training manual for traditional practitioners in primary healthcare, and formalizing Traditional Healer Guilds in the each province. Traditional medicine program has featured in National Health Plans since 2001 (Govt. of PNG, 2012). Cost of traditional medicine is not covered by the Government. This policy provides a sound basis for defining the role of traditional medicine in national healthcare delivery, ensuring that the necessary regulatory and legal mechanisms are created for promoting, maintaining and development of traditional medicine, and that the authenticity, safety, efficacy, quality and rational use of therapies are assured. Besides enabling wider health coverage, introduction of traditional medicine into primary healthcare will reduce Government's medical expenditures. This is important at a time of severe financial constraints that the country is facing, particularly in terms of the funds available for purchase of modern drugs and medical supplies, and for providing human resources to health centres and aid posts. There is limited information on the number of traditional medicine practitioners in PNG. The national traditional medicines database (Ambihaipahar and Rai, 2004) lists over 850 practitioners but the total number may be much higher. There are currently no exclusive traditional medicine training or education programs at college or university level and no traditional medicine research institute in PNG.

Quality and safety of traditional medicine

Currently, there is no regulation for herbal medicines or the practice of traditional medicine, though laws relating to the National Policy on Traditional Medicines (2007) are currently in development. The WHO has strongly advocated the use of quality traditional medicines and developed guidelines for member countries to adopt. The Traditional Medicines Database, first started in 1999, holds details on medicinal plants and traditional medicines, and is viewed as a national resource. The Traditional Medicines Task Force, established by the NDoH in PNG in 2004, has been given the responsibility to identify candidate herbal medicines from the database for inclusion in the primary healthcare formulary.

Herbal medicines are sold in local markets with medical, health and nutrient content claims. PNG has no pharmacopoeia. However, "Medicinal Plants in Papua New Guinea" written and compiled by Rai and colleagues was published in 2009 with support from the WHO regional office. This publication describes traditional uses of 126 medicinal plants (WHO 2009). It is evident that the lives of most of the tribal groups in PNG are intimately linked to their environment. This extended habitation by various tribal groups of diverse environments has led to an especially

rich tradition of medicinal plant use in PNG. Although many of the early botanical expeditions collected notes on traditional use, they have not been systematically assessed with respect to medicinal records, nor disseminated.

The National Health Plan of PNG, 2001-2010, adopted by the NDoH, created a Traditional Medicines Working Group to assist in the development of traditional medicines in the country. As an outcome of this early work, the University of Papua New Guinea initiated a country-wide survey on traditional medicine practice, the collection of medicinal plant voucher samples, and developed the above mentioned database. The database provides the Task Force with validated information concerning particular medicinal plant uses. The database contains comprehensive information on up to 4,000 traditional medicines derived from 1,000 plant species. The database is dedicated to documentation and preservation of traditional knowledge concerning medicinal plant use in PNG and to serve as repository of indigenous knowledge in traditional medicine. It is also used to identify safe and effective traditional medicine practices and promote their usage in the community. There are four major categories in the database: prescription database, chemistry and pharmacology database, photo-image database, and practitioner database. Medicinal plants of commercial potential are listed in Table 1, and the most commonly used plants in PNG traditional medicine are listed in Table 2. Diversified uses of some commonly used plants are listed in Table 3.

Table 1. Distribution of medicinal plants of commercial potential in PNG

Plant species	Region	Name of oil
Cryptocaria massoy	All coastal regions	Massoia oil
Canaga odorata	All coastal regions	Canaga
Jasminum sp.	All coastal regions	Jasmine
Drimis peperita	Tabubil and some highlands region	Drimis
Pongostemon cablin	Most regions of PNG	Patchouli
Piper nigrum	Most regions of PNG	Pepper
Kaempfera sp.	Central province	Kaempfera
Santalum macgrogreii	Central province	Sandalwood
Aquilaria sp.	Most coastal provinces	Eaglewood
Euodia hortensis	Many provinces of PNG	Euodia
Rosa damacena	Cooler parts of highlands	Rose
Polyanthus tuberosa	All coastal regions	Tuberose
Mentha sp.	Highlands	Mint
Curcuma longa	All coastal regions	Turmeric
Elettaria cardamomum	Most parts of PNG	Cardamom
Acorus calamus	Highlands	Acorus
Piper gibbilimbum	Highlands	Gibbilimbol
Melaleuca platyphylla	Western province	Melaleuca

Table 2. The most common 100 medicinal plants used in PNG traditional medicine*

Abelmoschus manihot	*Derris elliptica*	*Morinda citrifolia*
Abrus precatorius	*Desmodium umbellatum*	*Ocimum basilicum*
Acalypha wilkesiana	*Dioscera alata*	*Pandanus tectorius*
Ageratum conyzoides	*Dioscorea bulbifera*	*Pangium edule*
Alstonia scholaris	*Eleusine indica*	*Paspalum conjugatum*
Alstonia spectabilis	*Endospermum formicarium*	*Passiflora foetida*
Angiopteris evecta	*Endospermum medullosum*	*Pedilanthus tithymaloides*
Areca catechu	*Epipremnum pinnatum*	*Persea americana*
Artocarpus altilis	*Erythrina variegata*	*Pipturus argenteus*
Asplenium nidus	*Euodia hortensis*	*Plectranthus scuttelariodes*
Averrhoa carambola	*Euphorbia hirta*	*Polygala paniculata*
Bidens pilosa	*Fagellaria indica*	*Pometia pinnata*
Bixa orellana	*Ficus adenosperma*	*Premna obtusifolia*
Breynia cernua	*Ficus copiosa*	*Premna serratifolia*
Calophyllum inophyllum	*Ficus septica*	*Psidium guajava*
Capsicum annum	*Ficus wassa*	*Pterocarpus indicus*
Carica papaya	*Flagellaria indica*	*Ricinus communis*
Cassia alata	*Gnetum gnemon*	*Rungia klossii*
Casuarina equisetifolia	*Hibiscus rosa-sinensis*	*Scaevola tacadda*
Casuarina papuana	*Hibiscus tiliaceus*	*Sida rhombifolia*
Catharanthus roseus	*Homalium foetidum*	*Solanum torvum*
Centella asiatica	*Hornstedtia scottiana*	*Solanum tuberosum*
Citrus limon	*Imperata cylindrica*	*Sphaerostephanos alatellus*
Cocos nucifera	*Inocarpus fagifer*	*Sphaerostephanos unitus*
Codiaeum variegatum	*Ipomea pes-caprae*	*Sterculia ampla*
Coleus blumei	*Jatropha curcas*	*Syndrella nodiflora*
Commelina paleata	*Kalanchoe pinnata*	*Syzygium malaccense*
Cordyline terminalis	*Laportea decumana*	*Terminalia cattapa*
Costus speciosus	*Macaranga aleuritoides*	*Timonius timon*
Crinum asiaticum	*Mangifera indica*	*Vitex trifolia*
Curcuma longa	*Manihot esculenta*	*Wedelia biflora*
Cyclandophora laurina	*Merremia peltata*	*Zingiber officinale*
Cymbopogon citratus	*Metroxylum sagu*	
Cyperus rotundus	*Mikania micrantha*	

*Based on data obtained from the National Database on PNG Traditional Medicine [Ref: 39]

Table 3. Diversified uses of medicinal plants found in PNG

Plant species	Habitat	Distribution	Traditional uses
Abelmoschus manihot	Cultivated everywhere in the gardens all year round.	Common throughout the country and used as an important vegetable	Vegetable, infertility, dysentery, skin rashes, cold, etc.
Alstonia scholaris	A common lowland tree species in primary and secondary forest.	Common tree throughout Papua New Guinea	Used in traditional medicine to treat diarrhoea, fever, etc.
Areca catechu	Grows in savannah belt; commonly cultivated about the houses	Distributed throughout the tropics; a major crop in PNG	Agricultural crop; betel nut is chewed with lime and leaves of *Piper betle* as a mild stimulant
Bidens pilosa	Weed of vegetables and other crops; common in wasteland, throughout the region.	Widely distributed along trails and roads, in cultivated areas.	To treat boil, red and sore eyes
Calophyllum inophyllum	Common along beaches and seashores	Distributed around coastal areas of PNG and quite common on islands	Skin infections, cut and sores including tropical ulcers and boils
Cassia alata	Grows wild in rainforest and wet habitats	Widespread throughout the tropics	Grielle and parasitic skin diseases
Centella asiatica	Common in lawns and open areas	Widely distributed throughout the tropics	To treat amnesia, diabetes, high blood pressure, anxiety and fatigue
Crinum asiaticum	Seashores and sandy beaches	Widely distributed in the coastal areas in South Pacific	Cuts, wounds and scabies sores
Cymbopogon citratus	Coastal areas, grows well in fertile and well drained soil	Grown or introduced in all inter-tropical regions	Cold, cough and fever
Dodonaea viscosa	Grows mostly in highland grassland	Widespread, often seen in desert landscapes	To induce sterility, boils and tropical sores
Erythrina variegata	Common in agricultural areas	Lowland coastal regions	Cough, sore throat, to reduce swellings
Ficus septica	Found in low secondary growth, rainforest, old garden clearings.	Everywhere in PNG, upto an altitude of about 1500 m.	As timber, whooping cough
Ipomoea batatas	Cultivated species	Planted throughout PNG	Common food crop, treatment of sores
Metroxylon sagu	Found in swamp, wet and soft soil	Widely distributed and cultivated palm tree	Common starch food, antodiarrhoeal
Musa paradisiaca	Commonly found on tropical lowland areas	Widely cultivated	Cooking banana, fresh cuts and sores

Contd...

Table 3 (contd...)

Plant species	Habitat	Distribution	Traditional uses
Morinda citrifolia	Occasional to common in coastal vegetation and house yards	All coastal regions of PNG	Tonic and wellness drink, aches and pains, fever, diarrhea and dysentery
Ocimum basillicum	Grows well in warm climates	Cultivated in PNG	As flavoring agent, treatment of fever
Pometia pinnata	Lowland forest	Cultivated in village gardens	Firewood, oral contraceptive
Psidium guajava	Cultivated as fruit tree around the house	Found in lower altitude throughout PNG	Common fruit, diarrhea and other conditions
Pterocarpus indicus	Found in primary and secondary forests	Widely distributed	A quality timber used in house construction, to induce menstruation
Saccharum officinarum	Cultivated in gardens and field	Well distributed in all parts of PNG	A commercial crop for production of sugar, also used to stop diarrhea and motion sickness
Syzygium malaccense	Cultivated for its edible fruit	Widely distributed	Fruit edible, cold and cough
Zingiber officinale	Grown as culinary plant	Common garden plant throughout PNG	Used in food as spice, to treat cough and cold

Future Thrusts

Rising consumer interest in use of natural and organic products, sustained demand for medicinal and aromatic plants worldwide (Salopuka, 2012) and growing acceptance of alternative and complimentary medicines by health policy makers make it prudent for country like PNG to formulate policies and plans to use these resources for economic and health benefits of its people. Scientifically validated and standardized herbal products are in great demand and data are available to develop some suitable products from PNG herbs (Barrows *et al.,* 2009).

Using proprietary information accumulated in the National Database on Traditional Medicine in PNG, it is possible to identify effective herbal preparations for range of conditions such as energy boosting, relaxation and sleep aid, HIV, pneumonia, cough suppressant, topical antibiotic and antifungal, pain or headache, fever, etc. PNG offers huge scope for development of small, medium and large scale industrial production of medicinal and aromatic plants. Timber logging which is one of the main income generation activities at present is detrimental to the sustainability of flora and is impacting adversely on ecology and biodiversity of the land. It is incumbent upon the relevant Government agencies and departments, namely, Department of Environment and Conservation; Dept. of Agriculture and Livestock; PNG Forest Resource Authority; National Forestry Research Institute of PNG; National Agriculture Research Institute; Dept. of Trade and Industry; National Dept. of Health; and Dept. of Planning to formulate policies and action plans to address this important but hitherto neglected area. There is also scope for private sector to explore and engage in

economic ventures utilizing medicinal and aromatic plants. Commercial production of some of these plant species will generate much needed income for village communities, and also help conserve valuable plant resources.

PNG is endowed with vast resources of medicinal and aromatic plants. Apart from traditional ways of using them in healthcare, many can be exported as raw materials to industrialized countries for processing. United Nations Organization for Industrial Development (UNIDO) has developed programs to industrially process these plants to establish agro-based industries in developing countries. Existing technologies for processing medicinal and aromatic plants can be adopted to suit the local situations. Designs and specifications for this pilot plant have been published to enable countries to fabricate it locally. Industrial scale activities may include production of standardized and good quality traditional medicines and extracts, formulation of extracts into modern dosage forms, and development of drugs and the production of essential oils, etc.

Conclusion

Global herbal supplements and remedies market is forecast to reach US $107 billion by the year 2017. PNG is known as a treasurehouse of valuable medicinal and aromatic plants. It is a small nation with rich biodiversity. PNG has an estimated 20,000 vascular plant spp. that offer tremendous opportunity for exploration, cultivation, production, and commercialization of plant products (John, 2012; Rali, 2013). So far little has been done in this regard. Government support in establishing herbal industry, cooperation and collaboration from private sector, government agencies, research institutions, and universities are needed to develop this sector.

It is important that valuable plant species are not only conserved but also promoted for commercial cultivation in order to meet the increasing demand especially in the export markets. Efforts should be made to develop suitable herbal products from indigenous plant species with in-built quality control and standardization measures. It is believed that production and accessibility to quality herbal products within PNG will have positive impact in improving health standards of its people. There is demand locally and overseas for quality herbal products. PNG, with its rich traditional knowledge and plant resources, need to harness this potential.

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Country Status Report on Medicinal and Aromatic Plants in the Philippines

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Introduction

The Philippines located at 13°00'N 122°00'E is an archipelago of about 7,100 islands, with a population of 92.34 million in 2010 and annual growth rate of 1.9 per cent (NSO, 2013). Two distinct seasons predominate in the country – the wet (June - November) and dry (December – May) seasons, with a mean annual rainfall from 965-4064 mm, relative humidity from 71-85 per cent and temperature from 25.5°C-28.3°C (PAGASA, undated). It is visited by an average of 19-20 tropical cyclones per year.

The Philippines has been blessed with rich natural resources. It is one of the world's 18 mega-biodivesity countries, harboring 70-80 per cent of the world's plant and animal species (RP, 2009). About 67 per cent of the total 52,177 species of flora and fauna are considered endemic (Altoveros and Borromeo, 2007). Philippine plant species estimate ranges from 13,500 - 15,000, of which more than 3,500 are considered indigenous and with around 1,500 classified as medicinal plants (Eusebio and Umali, 2004; Altoveros and Borromeo, 2007; Galvez Tan, 2013). Quisumbing (1951) provides a description and therapeutic uses of 858 local plant species in his book "Medicinal Plants of the Philippines". A more recent information related to Philippine medicinal plants can be sourced from de Padua *et al.,* (1999) and van Valkenburg and Buyapraphatsara (2002). The published reports on the inventory of plants whose primary use is for the extraction of essential oil in the Philippines are rather fragmentary. Brown (1921) initially characterized 25 species of essential oil plants in the Philippines. Oyen and Nguyen Xuan Dung (1999) provides a list and description of 60 major and minor essential oil plant species that are widely distributed in the Philippines and the neighbouring countries of Southeast Asia.

Support for the development of MAP industry in the Philippine through active research and promotion of MAP and their subsequent commercialization have been provided by several Government and academic institutions. The Philippine Institute for Traditional and Alternative Healthcare (PITAHC), a line agency of the Department of Health (DOH), was created through the Traditional and Alternative Medicine Act (TAMA) of 1997. It serves as the focal institution tasked to address the present needs of the people on healthcare through the provision and delivery of traditional and alternative healthcare (TAHC) products, services and technologies that have been proven safe, effective and affordable" (www.pitahc.doh.gov.ph). On the other

hand, the Philippine Council for Health Research and Development (PCHRD), a sectorial council of the Department of Science and Technology (DOST), is responsible for coordinating and monitoring research activities, including the programming and allocation of government and external funds related to health science and technology development in the country (www.pchrd.dost.gov.ph). PCHRD has financially supported the National Integrated Research Program on Medicinal Plants (NIRPROMP). PCHRD has also identified a list of 164 priority medicinal plants for research and development. Academic institutions have also been actively engaged in conducting research on MAP. Collaborative interdisciplinary efforts among the three constituent units of the University of the Philippines (UP) – UP Manila (lead unit of the Program), UP Diliman and UP Los Baños – have provided the major research backup for the NIRPROMP, which is credited with the identification and scientific validation of the 10 Philippine medicinal plants. These 10 species are currently being promoted by DOH and PITAHC. Private universities such as Ateneo de Manila University, De La Salle University and the University of Sto Tomas are also actively engaged in research on MAP.

MAP species have long been used in the Philippines, particularly in the rural areas, where access to modern medical healthcare and medicines is very limited. Traditional healers, estimated to be around 250,000 in the country in 2002, have been providing alternative healthcare through the use of indigenous MAP (PCHRD, 2012). The underlying importance of the use of MAP is also reflected in the observation that there is only one medically trained doctor for every 80,000 Filipinos as compared to one traditional healer for every 300 people. A study conducted by Dahilig and Salenga (2012) in selected communities in the Philippines revealed that the prevalence of the use of complementary and alternative medicine (CAM) was higher among rural respondents (68.4%) compared to their urban counterparts (51.1%), with both users claiming CAM to be beneficial. The recent interest on health and wellness products locally and globally has further underscored the importance of MAP. These products range from traditional herbs with purported healing properties to culinary herbs, spices, essential oils to the more popular herbal food supplements, and related organic and functional foods. In the Philippines, the wellness industry had grown from scratch to worth US $ 25.3 million in 2012 (Belena, 2013). It is predicted that by the year 2022, tourism and alternative healthcare will emerge as the world's biggest industries. The Philippines is expected to play a pivotal role in this industry for the following reasons: availability of educated pool of professionals, natural wealth and a wide range of medicinal herbs and aromatic plants. The increasing demand for health and wellness products has been spurred by: i) an increasing incidence of aging population, ii) consumer awareness about general health and well-being, primarily through the internet, iii) high prices and low availability of drugs which have become unaffordable to the majority of Filipinos and iv) a changing lifestyle that has contributed to the prevalence of most of the killer diseases in the country (Batangan and Juban, 2009; HAIN, 2009; NSO 2013). The above scenario is expected to further enhance a growing interest on MAP species.

Area, Production and Productivity

There is no comprehensive Government statistics on the production of MAP species in the Philippines. Data on the area and volume of production of some MAP in 2012 obtained from the Bureau of Agricultural Statistics (BAS), the Government agency officially responsible for collating statistics relevant to the production of various agricultural crops grown in the

country, are presented in Table 1. The list is not considerably long and does not include some MAP that are also cultivated in the country. In the short enumeration, except for lemon grass, which is classified as an aromatic plant, the rest are considered as medicinal plants. It should be emphasized that only *lagundi* and *yerba buena* have been scientifically validated for their therapeutic properties and are officially endorsed by the Philippine Department of Health (DOH). Among those classified as medicinal plants by the BAS, *banaba*, popularly used as an herbal supplement for diabetes, has the largest area officially recorded. About 23 per cent of this area is concentrated in the Ilocos Region in the north, followed by 13 per cent in the Davao Region in Mindanao. Production of *lagundi*, a medicinal drug used to treat cough, is fairly distributed in the country, with largest area in the Davao Region (17%) followed by the Northern Mindanao region and the province of Palawan, each contributing about 15 per cent to the total area. Oregano, which is popular also for the relief of gaseous distention and superficial burns, is produced for the most part in Northern Mindanao (18%), but small plantings can be seen in almost all the regions of the Philippines. A little over 30 per cent of the production of *Yerba buena*, which has analgesic properties, is found in the Central Visayas.

Table 1. Area and production of important medicinal plants in the Philippines (2012)

Medicinal plants			Area (ha)	Production (tons)
Scientific name	**English name**	**Local name**		
Vitex negundo L.	Five-leaved chaste tree	Lagundi	41	97
Coleus amboinicus Lour.	Country borage	Oregano	28	56
Mentha × *cordifolia* Opiz ex Fresen	Mint	Yerba buena	16	15

Source: Bureau of Agricultural Statistics (2013)

Among the various potential aromatic plants, the data only for lemon grass are officially included in BAS list. For 2012, the area and volume of production of lemon grass amounted to 603 ha and 2,334 tons, with an estimated yield of 3.9 tons/ha. The largest site of production can be found in Northern Mindanao, the region contributing about 21 per cent of the total production area in the Philippines, followed by Central Visayas (18%) and Davao Region (15%). Not captured in the BAS database two other important essential oil plants – ilang-ilang and citronella are not included. About 2,000 trees are currently planted along the roads and backyard areas of the municipality of Anao, Tarlac and about 1,000 trees have been established by a private individual in Pura, also in Tarlac. An ilang-ilang tree produces from 36-50 kg of flowers per year. On the other hand, the plantation of citronella is concentrated in the province of Biliran in the Visayas region. About 50 ha is planted under this aromatic crop.

It should also be noted that there are other plants marketed as herbal teas and supplements with some commercial production. A case in point is the crop *malunggay* or horseradish tree (*Moringa oleifera* Lamk.), more commonly used as a vegetable crop but currently promoted as a plant with reported medicinal properties. Based on the inventory of the Moringaling Philippines Foundation, Inc., an umbrella organization promoting the cultivation and use of *malunggay*, a total of 50 ha is currently planted under the crop mostly in the Bacolod area in the south and the Ilocos Region in the north of the country (MPFI, 2013).

Major Uses

Major uses of important MAP species in the Philippines are given in Table 2. The therapeutic properties of the listed medicinal plants have been scientifically validated by the NIRPROMP. Only 5 herbal products out of 98 medicines have been included in the Essential List of Primary Care Medicines published by the Philippine National Drug Formulary (PNDF, 2008). These include *Yerba buena* as analgesic, *lagundi* for cough, *tsaang gubat* as antispasmodic, *akapulko* as antifungal and *sambong* as diuretic. The list identifies the medicines that are "useful in meeting the immediate needs of the great majority of the population for commonly encountered ailments all over the country".

Other important crops with medicinal properties popularly marketed as herbal teas and dietary supplements in the country are *banaba* and *malunggay*. *Banaba*, as mentioned earlier, has been shown to possess hypoglycemic practices (Drugs.com, 2013). *Malunggay* leaves are highly nutritious and have been used traditionally in the Philippines to induce lactation in breastfeeding mothers. On the other hand, the essential oil derived from most

Table 2. Important plant parts and uses of major MAP species

Botanical name	English name	Local name	Plant part(s)	Major uses
Medicinal plants				
Blumea balsamifera (L.) DC.	Ngai camphor plant	Sambong	Leaves	Diuretic; anti-urolithiasis
Mentha x *cordifolia* Opiz ex Fresen	Mint	Yerba buena	Leaves	Relieves body pain
Peperomia pellucida (L.) Kunth	Shiny bush	Ulasimang bato	Shoot	Lowers blood uric acid level
Quisqualis indica L.	Rangoon creeper	Niog-niogan	Fruits	Anthelmintic
Senna alata (L.) Roxb.	Ringworm bush	Akapulko	Leaves	Skin fungal infection
Vitex negundo L.	Five-leaved chaste tree	Lagundi	Leaves	Expectorant; bronchodilator
Aromatic plants				
Cananga odorata Hook. F and Thoms.	Ylang-ylang	Ilang-ilang	Flowers	Perfume raw materials
Cymbopogon winterianus Jowitt	Citronella	Citronella	Leaves	Manufacture of soaps, detergents, mosquito repellents, household cleaners
Cymbopogon citratus (DC.) Stapf	Lemon grass	Tanglad	Leaves	Masking fragrance in deodorants, detergents and pesticides
Pogostemon cablin (Blco) Benth	Patchouli	Kablin	Leaves	Base materials in perfumery; fixative; soaps, cosmetics and incense

Source: Cortes-Maramba et al., 1982; de Guzman et al., 1997

of the enumerated aromatic plants are popularly used in the manufacture of local perfume, scented candles, detergents and various types of personal care products such as soap and shampoo.

Significant Achievements

Germplasm collection, characterization and conservation

The collection and conservation of MAP genetic resources are taken care by the National Plant Genetic Resources Laboratory (NPGRL) of the Institute of Plant Breeding (IPB) in the College of Agriculture (CA), University of the Philippines Los Baños (UPLB). NPGRL is the national centre for conservation and utilization of important and potentially useful agricultural crops in the Philippines. A total of 71 MAP species are maintained in the collection. Currently, the bulk of the activities of NPGRL on MAP is on collection and characterization. The collections are established and maintained in the field. Other Government institutions that collect and conserve these important commodities in their botanical gardens include: i) the Crop Physiology Division of the Crop Science Cluster (CSC), CA-UPLB, where around 73 species of MAP have been established; ii) the Bureau of Plant Industry of the Department of Agriculture (DA) located in Manila which maintains around 67 species of culinary herbs, spices, essential oil plants and medicinal plants, and iii) the Los Baños Experiment Station (LBES) of the Environment Research and Development Bureau (ERDB), Department of Environment and Natural Resources (DENR), which has established a field gene bank containing about 180 MAP species.

Variety development

Currently, there is not much variety development research work being done on medicinal and aromatic plant species in the country. However, there is an urgent need for undertaking concerted variety improvement program in order to address the emerging challenges and promote the use of MAP in the Philippines.

Cultivation practices

The growing requirement for medicinal plants are understandably more stringent than the other agricultural crops (Quintana, 2008). The medicinal plants must be cultivated at least 1 km away from major roads and farms where chemical pesticides are sprayed. The soil should be loose and free from toxic metals. A clean water source should be available. Except for *ulasimang bato*, which prefers partial shade, all the priority medicinal plants thrive best under full sun. *Akapulko* and *tsaang gubat* can also tolerate partial shade.

The cultivation requirements/practices for selected MAP species are given in Tables 3 and 4. Most of the medicinal plants recommended by DOH are propagated asexually, usually in the form of cuttings. Seeds are commonly used in the propagation of *ampalaya* and *ulasimang bato*; these are also alternative planting materials for *akapulko* and *tsaang gubat*. Propagation using tissue culture techniques have also been developed for *tsaang gubat* (Reglos-Zara *et al.,* 2010), *lagundi* (Cedo, personal communication), *sambong* (Necesario, 1994; Soriano and Cangao, 2009), and *ampalaya* (Aspuria, personal communication) at UPLB. All the aromatic plants enumerated in Table 4 are commonly propagated using asexual techniques, except

for *ilang-ilang*. A micropropagation method has also been reported for *ilang-ilang* (Lindain *et al.,* 2008).

At present, there is no established recommendation for fertilizer application in local MAP species. The figures given in the tables are results of initial research studies that need more in-depth investigations. These studies involve mostly the use of chemical fertilizers. Some preliminary studies on the use of organic fertilizers have also been conducted on *ampalaya*, *tsaang gubat* and *sambong*.

Table 3. Cultivation practices for selected medicinal plants

Crop	Propagation	Planting distance	Fertilizer application
Blumea balsamifera (L.) DC.	Stem or root cuttings	0.5-10 m × 1-1.50 m	40 g (14-14-14)/plant at transplanting and after every harvest; 0.5-2 kg dried ipil-ipil leaves
Mentha × *cordifolia* Opiz ex Fresen	Stem cuttings	45 cm × 60 cm	10 g (14-14-14)/plant at planting and after each harvest
Peperomia pellucida (L.) Kunth	Seeds	25 cm × 50 cm	no reported data
Quisqualis indica L.	stem cuttings	4 m × 4 m	10 g nitrogenous fertilizer/plant 1 month after transplanting; 2 bags (14-14-14)/ha after every 6 months
Senna alata (L.) Roxb.	seeds or stem cuttings	1.5 m × 3.0 m	1 bag/ha ammonium sulfate 3 weeks after transplanting; 1 bag/ha after 2 months
Vitex negundo L.	mature, leafless stem cutiings	1.0 m × 1.5 m	0.5 – 2 kg fresh ipil-ipil leaves or 10-50 g (14-14-14)/plant at planting and after harvest

Source: Quintana (2008); Quintana and Mabesa (2008); Series of Information Bulletins on the priority medicinal plants jointly published by PROSEA and PCARRD-DOST (2005 and 2006); de Padua et al. (1999)

Table 4. Cultivation practices for selected aromatic plants

Crop	Propagation	Planting distance	Fertilizer application
Cananga odorata Hook. F and Thoms.	Seeds	5 m × 5 m	For transplanted seedling: 1.78 g (14-14-14), 1.25 g (16-20-0); 1 g (21-0-0) and 20 g composted chicken manure; for mature trees: 500 g (14-14-14) at start of wet season and 200 g urea 4 months later
Cymbopogon winterianus Jowitt	Slips	0.5-0.9 m × 0.6-1.0 m	Basal application: 35 g/m^2 (14-14-14); topdress 10 g/m^2 urea and 10 g/m^2 muriate of potash 2 and 4 months after planting
Cymbopogon citratus (DC.) Stapf	Slips or offshoots	0.5-0.6 m × 0.5-0.9 m	30 kg each of N, P_2O_5 and K_2O, followed by 60 kg N/ha in split applications after each harvest per year
Pogostemon cablin (Blco) Benth	Stem cuttings	0.4-0.5 m × 0.5 m	35 g/m^2 (14-14-14) at planting; then topdress 10 g/m^2 urea and 12.5 g/m^2 muriate of potash 2 months after planting

Source: de Guzman et al. (1997); Oyen and Xuan Dung (1999)

Harvesting time of the priority medicinal plants ranges from 2-8 months after planting and for most plants, can be repeated 1-5 months thereafter (Table 5). Healthy leaves are generally harvested from the upper portion of the shoot.

Table 5. Harvesting of medicinal plants

Crop	Plant part	Time of harvesting	Method of harvesting
Mentha x *cordifolia* Opiz ex Fresen	Leaves	2-3 months after planting and 1-2 months thereafter	Cut the healthy top shoots
Peperomia pellucida (L.) Kunth	Whole plant	2.5-3 months after planting	Gather whole plant and remove the roots
Quisqualis indica L.	Fruits	2-3 years after planting	Harvest yellow or coffee-brown fruits
Senna alata (L.) Roxb.	Leaves	5-6 months after planting and 4 months thereater	Cut stems 0.75 m from the ground and harvest healthy leaves
Vitex negundo L.	Leaves	7-8 months after planting and 3-5 months thereafter	Cut stems 0.75 m from the ground and harvest healthy leaves

Source: Quintana (2008)

For the aromatic plants citronella, lemon grass and patchouli, the leaves are harvested from 6-8 months from planting and 2.5-6.0 months thereafter. The leaves are air-dried prior to extraction of essential oils. Flowering in ilang-ilang generally starts in 2-3 years and flowers are harvested about 20 days after blooming, indicated by a change of colour from green to yellow.

Disease and pest management

Some of the reported diseases, insect pests and weeds of some of MAP species are provided in Tables 6 and 7. Since the use of pesticides are prohibited in medicinal plants, control measures have been limited to ensuring the health and vigour of the plant through provision of water and judicious application of fertilizer and maintaining the over-all cleanliness of the farm through regular weeding, immediate removal of infected plant parts, and use of clean and healthy planting materials. Some farms use various plant preparations but the effectivity of these in the control of pests has not been fully scientifically tested.

Production of quality seed and planting material

The seeds and planting materials designed for production of medicinal plants should be free from diseases and insect pests, not contaminated with toxic metals and should be derived from healthy and vigorous mother plants. More importantly, the planting materials should also be sourced from those that have been scientifically validated. At present, there are no accredited plant nurseries in the Philippines that carry certified seeds or planting materials for MAP species. The main source for some of the priority medicinal plants, except for *ampalaya*, is the NIRPROMP. The 'Makiling' variety of *ampalaya* recommended for medicinal plant production is obtained from a private seed company. Some institutions like the Bureau of Plant Industry (BPI)-DA and the CSC-UPLB can also provide the appropriate planting materials. Materials for aromatic plants can be sourced from some local Government units that are actively involved

Table 6. Diseases and pests of some important medicinal plants

Crop	Diseases and pests
Blumea balsamifera	Diseases: Leaf rust – *Endophyllum blumeae;* Leaf spot – *Circospera* spp.
Quisqualis indica L.	Diseases: *Cercospora* leaf spot; Leaf blight; Sooty mold Insect pests: Leaf roller; Scale insects
Senna alata (L.) Roxb.	Diseases: Root rot – *Phytoptora* sp.; Bacterial wilt – *Ralstonia solanacearum* Insect pests: Common emigrant – *Catopsilia crocale*; Pyrallid moth – *Agriphila* sp.; Psyllid – *Psyllidae* sp.
Vitex negundo L.	Diseases: Leaf spot – *Cercospora* sp.; Circular leaf spot – *Corynespora* sp. Insect pests: Leaf beetles – Chrysomilidae; Lace bug – Tingidae; Leaf folder – Pyraustidae; Cutworm – Noctuidae; Leafhopper – Cicadellidae Weeds: Cogon – *Imperata cylindrical* (L.) Beauv. Var. Koenigii; Makahiya – *Mimosa pudica* L.; Gatas-gatas – *Euphorbia hirta* L.; Mutha – *Cyperus rotundus* L.; Cleome – *Cleome rutidosperma* DC.; Itch grass – *Roetboellia cochinchinensis* (Lour.) W.D. Clayton

Source: Quintana (2008); Series of Information Bulletins on the Philippine priority medicinal plants jointly published by PCARRD-DOST and PROSEA (2005, 2006).

Table 7. Diseases and pests of aromatic plants

Crop	Diseases and pests
Cananga odorata Hook. F and Thoms.	Insect pests: Gray mealy bug – *Ferrisia virgata* Ckll.; White mealy bug - *Planococcus lilacinus* Ckll.; Atlas moth – *Attaccus atlas* L.; Leaf miner – *Phyllocnistis* sp
Cymbopogon winterianus Jowitt	Disease: Leaf blight – *Curvularia andropogonis* (Zimm.)
Cymbopogon citratus (DC.) Stapf	Diseases: Leaf spot disease – *Helminthosporium cymbopogi*; Leaf disease – *Curvularia lunata*
Pogostemon cablin (Blco) Benth	Diseases: Root-knot nematode – *Meloidogyne incognita* (Kofoid and White) Chitwood; Leaf blight – *Cercospora* sp.; Patchouli mottle virus – PaMoV; Patchouli mild mosaic virus - PaMMV

Source: de Guzman et al. (1997); Oyen and Xuan Dung (1999)

in the production and processing of this commodity (e.g. the municipalities of Anao, Tarlac for ilang-ilang and Biliran for citronella).

Primary processing, value addition and product development

Primary processing of medicinal plants basically involves selecting and separating the desired plant parts, removing dirt and unwanted substances, air-drying in well-ventilated and shaded areas and storing preferably in brown coloured bottles, away from sunlight (Quintana, 2008; Cortes-Maramba, 1982). The PITAHC currently has four processing units located in the cities of Tuguegarao, Tacloban, Cotabato and Davao. Major medicinal plants being processed into tablets are *lagundi*, *sambong* and *tsaang gubat*. The processing plants have the capacity to

produce 10-15 million tablets per year. The Cotabato processing unit also has the capacity to produce 180,000 herbal soaps per year.

Unlike medicinal plants, the commercial farm production of aromatic plants and their processing into essential oils is very limited (de Guzman *et al.,* 1996; 1997). Primary processing takes place at the site of cultivation. Except for *ilang-ilang*, the harvested leaves of citronella, lemon grass and patchouli are generally air-dried prior to extraction of essential oil. Ilang-ilang flowers are processed fresh, immediately after harvest. Hydro-steam distillation is commonly used method in the isolation of essential oil. The capacity of extractors ranged from 40- 700 kg raw materials.

Marketing, commercialization and trade

A study conducted by Cruz *et al.* (2011) revealed that 86 per cent of 1,809 adult respondents in 2008 in Metro Manila were aware of food supplements, considerably much higher than the 38 per cent level of awareness in 1998. Women (48%) were more aware of food supplements than men (37%). Among food supplements, herbal supplements and herbal teas were taken by 51 per cent and 28 per cent of the regular users, respectively, compared with 65 per cent regular users of single-nutrient food supplements. The top five herbal supplements for regular users include *ampalaya*, garlic, *sambong*, ginseng and *Gingko biloba*, while for herbal teas include green tea, lemon tea, ginger tea, *banaba* tea and taheebo tea. About 70 per cent of the respondents using food supplements suffered from diabetes and hypertension. The survey also validated the common perception that food supplements have positive effects on one's health.

With the growing interest on traditional herbal medicine in the country, several private companies ventured into the production and manufacture of medicinal plants and products, mostly in the form of herbal supplements and teas. Most of these companies have joined together to efficiently promote and market their products. The Chamber of Herbal Industries of the Philippines, Inc., (CHIPI), is an umbrella group of leading companies in the local natural and herbal market engaged in the manufacture, development, research, distribution and trading of herbal products (http://chipi.org.ph/about-us/). CHIPI started out with 12 companies in 2001 and grew to a current membership of more than 50 companies. As mentioned earlier, there is also the Moringaling Philippines Foundation, Inc. (MPFI), a network organization serving the moringa supply chain in the Philippines – farmers/ producers, processors/ manufacturers, health enthusiasts, suppliers, exporters and consumers of Moringa products (http://moringaling.net/).

Two pharmaceutical companies have actively participated in the production and marketing of herbal medicines. Pascual Laboratories (PascualLab), a Filipino-owned company, is the first pharmaceutical company to partner with DOST, PCHRD, and the NIRPROMP to commercialize the herbal medicines *lagundi* and *sambong* (PhilStar.com, 2012a). RiteMed, the leading unibranded line of medicines in the Philippines, and a division of the Filipino multinational United Laboratories, Inc. (Unilab), also marketed its first herbal product (StopCough Lagundi) in 2011, again in partnership with the NIRPROMP (PhilStar.com, 2012b).

Data on the Philippine export of MAP are available only in terms of value of export as a general commodity, with no identification of specific crop or product item. The FOB value

of export for 2012 amounted to US $ 206,026 for medicinal plants/seeds/fruits and US $ 2,167,508 for essential oils (dti.gov.ph). These data show that the Philippines is still a minor player in the global MAP industry.

Constraints and Opportunities

Constraints

As with other countries, modern medicine still dominates the pharmaceutical industry in the Philippines. At present, a total of 17,467 drugs and 1,837 food supplements (including herbal supplements) have been registered under the Food and Drug Administration (FDA) (FDA, 2014). In contrast, only 106 traditional medicines and 35 herbal medicines were approved by the FDA in 2013 (MB, 2013). These are mostly the products of the DOH such as *lagundi*, *sambong* and *yerba buena*. The data simply reflect the still limited availability of safe and high quality herbal medicines in the country. In a survey conducted in 2008-2009 in six regions of the Philippines, on the average, Filipinos spent about P485 for an acute illness and P 946 monthly for a chronic illness, amounting to 7 per cent and 15 per cent, respectively, of the total monthly household expenditure of P 6638 (Batangan and Juban, 2009). These costs were perceived to be relatively high and suggested the unaffordability of prescription drugs to most Filipinos.

Several constraints to the full development of the MAP industry in the Philippines have been identified by various sectors, including both private and Government institutions. The different stumbling blocks have been related to the aspects of MAP research, production and commercialization. Dr. Galvez Tan, the former Secretary of the DOH and an avid advocate of Filipino traditional medicine, enumerated several stumbling blocks as far as research is concerned. These include the: i) lack of investments in research and development; ii) lack of scientific collaboration between the private sector and the academia; and iii) low support for traditional medicine in academic institutions (Galvez Tan 2013). Dr. Rainier Villanueva, Founding President of the CHIPI, raised several research-related problems that beset the local herbal industry which included: i) lack of scientific basis to support various product claims; ii) no standardization of natural ingredients; iii) no clearing house or centralization of Government funded R&D studies, and v) lack of laboratory dedicated to the natural product industry (PCHRD, 2012). As mentioned earlier, an interdisciplinary research program on medicinal plants is presently being undertaken by the NIRPROMP. There is a need to infuse more research funds to the Program to accelerate the development of priority medicinal plants beyond the 10 being currently promoted by DOH. Critical financial research investment is likewise needed to establish a fully functional genebank dedicated to the conservation of MAP species. This genebank is envisioned to serve as the main source of genetic material for various research. In contrast to medicinal plants, no national research and development program exists at present on aromatic plants in the country.

The resurging interest on health and wellness products has attracted the production of some MAP species in the country, although to a limited extent as evidenced by the cultivation area provided by BAS. Production of raw materials of MAP has been constrained by the lack of or insufficient technologies on their cultivation and post-harvest handling. At the farm level, key interventions are particularly wanted in terms of nutrient requirement, appropriate methods

of control of insect pests and diseases, and primary processing. Villanueva also pointed out the minimal implementation of good agricultural practices among the agricultural producers (PCHRD 2012).

A need was feet for the local herbal industry to be globally competitive through public-private partnerships (PPP) (abs-cbnNEWS.com, 2010). Critical investments in research and development have not been made by both Government and private sectors to tap the international markets. There is also the difficulty of complying with the rigid regulatory requirements for herbal medicines by the targeted foreign countries.

The essential oil industry has not really taken off as major commercial endeavour in the Philippines despite the initial interest in aromatic plants way back in the 1990s. Various factors that impede its growth include: i) lack of or insufficient technology on agricultural production and primary processing of raw materials, ii) expensive and inefficient distillation equipment, iii) lack of financial support for farmers and processors who were interested in establishing their essential oil business, and 4) lack of marketing information (de Guzman *et al*., 1996).

Opportunities

Several opportunities exist for the growth and development of the local MAP industry. The abundant natural resources of MAP in the country have not been completely tapped, considering that only 10 medicinal plants are currently being endorsed by the DOH out of the potential 1,500 plant species. The list of 164 priority medicinal plants provided by PCHRD (1999) can provide an avenue for the available pool of young and veteran researchers alike to make a significant scientific dent in the field of local traditional medicine. The aromatic plants patchouli and ilang-ilang are indigenous to the Philippines and their essential oils have been important components of world-class perfumes. Market opportunities for MAP are definitely not wanting. The worldwide increasing trend in the population of the elderly (aged 65 and above) is a potential market for herbal products. For Southeast Asia alone, the elderly sector is projected to increase from 24 million in 2000 to 58 million in 2025, and to 129 million in 2050 (EWCRPPHS, 2002). In the Philippines, during 1970 - 2010, the older age group (65 years and over) has increased at a faster rate of 3.4 per cent per year compared with 1.5 per cent for the younger (0-14 years) and 2.8 per cent for the working (15-64 years) age groups (Albert, 2012).

The rapid advancements in science and technology, coupled by accessibility to various scientific research information through the internet, have engendered the personalization of medical care, including alternative or complementary health treatments. Consumers do not only surf the internet for health information but they also buy the products that will fit their lifestyle. According to Cloos *et al.* (2012) in most emerging markets in European Union and China, local players dominate the health business markets, offering a wide range, not only of health and wellness-related products but also services from nature spas to in-store clinics to gourmet establishments that offer herbal teas and organic-based culinary delights. Most of these trends have also been observed in the Philippines. Galvez Tan (2013) noted that patients are already inquiring if not requesting their physicians and healthcare professionals for complementary and alternative medicine.

Feasibility studies conducted by the ERDB on the production of the four medicinal plants *sambong*, *lagundi*, *akapulko* and *ampalaya* reveal that the projected net income per hectare can range from P 143,000 to P 421,800 for fresh leaves and from P 323,00 to P 1,141,800 when processed into dry leaves (Jose, 2003). The highest net income was obtained for *ampalaya*. These data suggest that there is financial opportunity in the production and primary processing alone of these medicinal plants.

The Philippines has already an established NIRPOMP that oversees an integrated research approach – from agriculture to clinical trials - to the development of an herbal drug. Its partnership with pharmaceutical companies have provided the final link that led to the popular commercialization and promotion of traditional medicine. Two of the product outputs of NIRPROMP, *lagundi* and *sambong* medicines, were reported to have sold a total of 3.3 million units as of 2009, amounting to P 430 million in gross sales revenues (abs-cbnNEWS.com, 2010). In 2012, the reported sales by two pharmaceutical firms of *lagundi* capsules and syrup as cough treatment reached P1 billion (Ronda, 2013).

Approaches for Meeting Emerging Challenges

Consultations with various stakeholders in the development of the local herbal industry have identified collaboration between Government and private sectors in the development of MAP as a key approach that can be adopted to meet the challenges of the growing herbal industry (PCHRD, 2012). The intimate linkage is needed to engender research studies that will scientifically validate the therapeutic properties of other priority medicinal plants and develop their cultivation and processing protocols. Both government research institutions and private stakeholders should in tandem identify MAP that could give the Philippines a competitive edge in the regional, if not global arena, of herbal medicine. This becomes more critical in view of the decision of the Association of Southeast Asian Nations (ASEAN) to fast-track the harmonization of the ASEAN Economic Community (AEC) aimed to create a single market and production base by 2015 (ASEAN, 2013).This approach is envisioned not only to minimize complete dependence on Government research funds but will also facilitate the immediate transfer of technology on and subsequent commercialization of MAP species.

Active promotion of the benefits and utilization of MAP species is extremely important. Not surprisingly, the sector that appears to be most resistant to the practice of traditional medicine (TM), including the utilization of herbal drugs, are the medically-trained doctors and other health professionals (Galvez Tan, 2013). Their rigid, scientific training patterned after the philosophy of Western medicine has made them less open to the potential benefits of TM. They need to be shown and be convinced of the clinical safety and efficacy of herbal drugs. On the other hand, producers and primary processors of MAP raw materials should be made aware of good agricultural and manufacturing practices (GAMP) that will ensure their sustainable production and processing. Consumers need to be educated on the identification and proper use of established MAP and on how to be discriminating of the various advertisements on MAPs and their purported therapeutic properties.

Future Thrusts

The following thrusts need to be given attention to fully realize the potential benefits that can be derived from MAP species:

- Address the various research gaps, coupled with the provision of sufficient government/ private financial support, on local MAP, from establishing the safety and efficacy of other priority medicinal plants to the development of more appropriate agricultural production and post-production technologies for some of the more established MAP species
- Establish a centralized genebank and a common analytical laboratory facility that will address the needs of various research and development efforts
- Provide and facilitate government assistance in the patenting and FDA registration of high quality herbal products
- Undertake an in-depth market analysis of the local herbal industry, particularly with regards to aromatic plants

Conclusion

The production, processing and marketing of MAP in the Philippines is still beset with various problems, but the opportunity for increased growth of the industry is wide open. Herbal medicines, in particular, have gained attention in recent years and much needs to be done to be able to meet the emerging challenges in the future. For the full development of the industry involving MAP, more capital investment is needed to sustain scientific research and marketing efforts on this important crop commodity, and this should be coupled with the active participation of both the government and the private sector.

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Country Status Report on Medicinal and Aromatic Plants in Korea

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Introduction

In the ancient times, the humans sought for medicine when they got sick or wounded and they often prescribed for utilizing plants, animals, and minerals for their healthcare. The plants have been used for spices and medicinal purposes as evidenced from the excavations from the Neanderthaler's tomb, approximately sixty thousand years ago. The record of curing patients with medicinal herbs around three thousand years ago was also found in the Egyptian mural. Moreover, there is a record of Hippocrates using drugs like a painkiller made from willow about 2,400 years ago in Greece. All of these historic evidences prove that medicinal herbs were already being used when humankind started getting food from nature for the first time.

Ayurveda, the outcome of traditional medical system that combines medical knowledge and wisdom, is still prevalent from 4,000 years in India. Furthermore, Shennong who is one of the Three Sovereigns in China was worshiped as a God of farming and medical science for teaching the way how to distinguish between medicinal herb and poisonous one about 4,500 years ago. In addition, Samguk Yusa (Memorabilia of Three Kingdoms) says that Hwanung (Supreme Divine Regent) made the bear and the tiger pray with twenty cloves of garlic for 37 days. This indicates that the independent medical system of ancient era has been established by using a plant that has strong properties of a medicine. In 561 A.D. in Korea, the first relevant record on medical science is about King Pyeongwon of Goguryo who brought the medical book from China and conveyed it to Japan. Besides, there are records of publishing books on medicine such as 'Baekje-shin-jibpang' in Baekje and 'Silla-beop-sabang' in unified Silla. Additionally, distinctive system from China on treating with medication was formed by publishing Hyangyak-gugeupbang during Goryo Dynasty and Hyangyak-jipseongbang during King Sejong 15 years period (1443).

Recently, the market of Korea is becoming more diverse due to decline in demand for herbal medicine and growth of consumer's demands on health functionality. The herbal tonics which used to account for the biggest demand, fell behind multi-vitamins and their demand significantly decreased. These have been changed into scientific chemicals and healthy functional products. In the meantime, prescribed oriental medicine combining with healthy foods and beauty-treatment goods such as cosmetic products, soap, and shampoo are gradually forming the new market.

Out of total species of the plants (4,200 species) that grow naturally in Korea, 1,000 species are of medicinal use. In fact, about twenty species such as licorice, *Rubus coreanus* fruit, lance asiabell, balloon flower, gigantic angelica, Chinese Matrimony Vine, etc. are the most frequently consumed ones. Licorice is the leading medicinal herb in Korea and it became indispensable. This goes well with the other sorts of medicinal ingredients by lessening toxicity and raising efficacy. The root of licorice not only strengthens spleen and stomach, but also reinforces the de-intoxication by activating the liver's function. Korean angelica root is a remarkable hematic which has great effects especially on women. In particular, it is highly beneficial for anemia, female disorders, and pregnant women who need recovery after childbirth by healing up their bodies. Moreover, it is highly effective for superficial wounds like bruise and sprain or on stimulating the circulation of the blood and alleviating the symptom of constipation. Cnidium is the main cause of unique fragrance from herbal medicine shop. Its young leaves are sometimes used as a vegetable. The root part of the cnidium works great in terms of pain-killing and relaxation from headache. It is often utilized as a stimulant and a suppressant for female disorder and helps promoting the circulation of the blood by combining with Korean angelica root.

Recently, the international pharmaceutical companies are observing carefully on new drugs that are made of natural substances and have less possibility of side effects. This is because the value of medicinal herbs attracted the attention as living resources and resulted in the establishment of a number of companies being very competitive for retaining and exploiting the resources which contain the medicinal components. Lately, the medicinal herb industry is inclined to be expanded with natural materials, functional foods, cosmetics, and household items. Especially, Korean herbal medicine and cosmetics industry has progressed very fast and became popular in the world with the popularity of Korean wave. In addition, tourism package and festival merchandise are being launched one after another.

Area, Production and Productivity

Medicinal plant species are not minor crops any more in Korea. The people around the world are interested in a variety of medicinal crops growing indigenously and being cultivated in both the orient and the occident. Owing to medicinal crops' indefinite applicability as functional medicinal food materials naturally to all the health industry, The R&D status of medicinal crops is expanding explicitly. In Korea, nation the wide production scale of medicinal crops was about 62,000 tons per year and cultivated, area was 13,000 ha in 2012.

Nowadays, consumers needs to have high quality products with high efficiency have raised alarm in the highly value-added industry. Various related science and industrial sectors have begun to realize its potential in advance. The potential of indeterminate growth in herb industry is the new national driving force in the future. Traditional usage of oriental herbs turn into various products processed by users' needs and consumer preference.

Major Uses

Medicinal herbs are constantly being developed not only as a raw material for medicine, but also as a foundation for an imperative life industry, functional foods, and industrial materials. In the field of medical supplies, its value is out of traditional herbal medicine market and being magnified in the capacity of materials for drug discovery. Additionally, the medicinal

herb is actively being advanced to be utilized into fresh vegetables and functional products by developing the cultivation techniques and making these suitable for healthy life. Unlike western herbs, the functional cosmetics and household goods which are made of our endemic herbs have strong medical actions so that it enables to create the niche market and results in emergence of various herbal products.

Herb for curing illness

The oriental medicine has been researched and complemented for many years by a huge number of people and recognized as an outcome of the traditional herb knowledge. The way of using medicinal herb which is mixed with doctor's experiences and folk remedy needs to be reinvented as well as the oriental philosophy in terms of the wisdom and intelligence of our ancestors. Likewise, consumers are gradually forming a new market by considering a variety of approaches/ methods as the scientific research outcome. These research results of modern science are coming as an advantage for conversion of understanding on the oriental medicine by proving the nutritional values and effective components of the medicinal herbs on curing illnesses. From ancient times, the main producers of medicinal herb at herbal medicine-market places like Geumsan and Jaecheon are advertising effectiveness and stimulating consumption through local events. The number of farms where they sell these well-known medicinal herbs through internet marketplace, website, and smart phone is continuously increasing.

Since distrust of consumers toward new synthesized medicine emerged in a developing country, exploiting a new medicine with natural substances began to dominate the marketplace. Developing new medicines such as anti-cancer and adult disease has provided a good scope to harness massive profits. Especially, a new medicine which is made of natural substance creates a market with high credibility. For instance, taxol of an anti-cancer medicine and tamiflu of a medicine for novel influenza use plants as raw materials and are the typical products that increased the profits tremendously.

The Korean standard of development on new medicine is not as much advanced as western one. However, Korea is competitive enough because of a plentiful amount of records regarding medicinal herbs which are raw materials for new medicines. 'Han-yak-gu-geup-bang' of Goryo and 'Hyang-yak-jip-seong-bang' of Chosun have good descriptions on unique characteristics, properties, and efficacy of medicinal plants. Moreover, Heo Jun's eastern medicinal manual and Lee Jema's 'Dong-eui-su-sae-bo-won' are the true outcomes of medical botany that explain the traditional knowledge over China, India, and western countries as well. 'Stilenjung', which was launched back in 2002, is gradually increasing the market share in the middle of heavy competition due to great functionality of Korean initial medicine that contains natural substances.

Medicinal herb as a healthy food

Health functional foods, especially the ones that include natural substances, are attracting the attention of the people who generate higher income and enjoy their leisure lives with better living conditions in modern society due to the concerns toward life extension and aging society. International market size was approximately US $ 269.7 million in 2008, while the domestic market size went up from US $ 675.5 million in 2005 to US $ 959.8 million in 2009 with 9.5 per cent annual average growth. Out of these, red ginseng that is a typical functional food reached a peak in sale volume worth US $ 499.5 million which indicates 53 per cent of the

total revenue from healthy functional food in 2009 for five years in a row. Nowadays, herbal medicine is not the primary use of herb anymore, but also as raw materials of functional foods for people's health improvement. Furthermore, some of the herbs are being used as fresh vegetables in many types of foods. Sprouts of turnip and chicory are used in Bibimbap and sandwich as sprout vegetables got popular. Consequently, restaurants that serve a variety of herbal cuisine are making inroads in the niche market. There are exclusive zones for oriental medicine to develop herbal cuisines in Youngcheon of Gyeongbuk and Jeongsun of Gangwondo as well. Since the herbal foods got popularized, many types of foods started to transform into healthier and more functional products such as healthy beverages, snacks, and even alcohol. The number of new launching products will be increased because the beverages and drinks consisting of herbal components make people feel free to enjoy it.

Medicinal herb as a beauty product

The products that transformed into modernized cosmetics from oriental cosmetics for the queens back in the history of Korea are getting more popular all over the world. The oriental cosmetics have captured 22.4 per cent (US $ 1,400 million) of the cosmetics market in Korea. Lately, there seems to be an inclination of Korean cosmetics market expanding throughout the world. The potential power of oriental cosmetics is expected to be enlarged as the trend of consumption regarding cosmetics began to focus on inner beauty. In addition, several pharmaceutical and food companies started aiming at the beverages and goods which are related to inner beauty for better market of 'edible cosmetics'.

Significant Achievements

The main tasks of the herbal crops research division are as follows: (i) to develop medicinal crop varieties and efficient breeding technologies, (ii) to study and improve the collection, conservation, evaluation, and proliferation of plant resources, (iii) to conduct research on improvement in cultivation methods and disaster mitigation, (iv) to investigate environmentally friendly and safe production and cultivation technologies, and (v) to develop technologies for better crop management after harvests and improve product marketability. In order to tackle these tasks effectively, three laboratories have been established: the Resource Development Laboratory, the Eco-friendly Production Laboratory, and the Quality and Safety Laboratory. A total of 14 people, including 4 scholars, 7 researchers, and 1 postdoctoral fellow, have been assigned the job. The Korean medicinal crops industry has recorded increase in its cultivation area and output due to the expansion of the wellness culture. Its products have diversified from simple medicinal materials to functional foods. In order to respond to these conditions, the herbal crop research division is undertaking trials to nurture superior medicinal crop species that could substitute imports and generate income, strengthening the supply base for medicinal crop seeds, securing consumer loyalty by improving medicinal crop production safety, and developing post-harvest technologies for pest and disease management.

Collection and conservation of medicinal crops

The mission of the laboratory is to undertake research on the collection, and conservation of MAP genetic resources. The development and distribution of high quality and stress-resistant medicinal crop varieties and development of new high income materials using medicinal plants

have also been undertaken. The Medicinal Botanic Gardens have also attracted attention of visitors interested in MAP. In addition, a conservation management system for medicinal plant resources by establishing National Medicinal Botanical Garden and Korea Medicinal Resource Herbarium has been undertaken. The National Medicinal Botanical Garden is composed of 9 theme gardens including 5 sense gardens (5 ha, 105 families, and 880 species). Increasing and evaluating the species diversity of genetic resources will contribute to the development of materials for manufacturing food, medicine and cosmetic products.

Technology to identify the origin of medicinal crops

Identifying the origin of medicinal crops is important and basic in the field of medicinal crop research. As imports of medicinal crops continuously increase, there is need to do further research in identifying the source of these medicinal herbs. This work was taken up to develop technology for distinguishing *Liriope platyphlla* from *Ophiopogon japonica*, *Angelica gigas* from *Angelica acutiloba at* various molecular levels. As a result, the Liriopis Tuber was developed as a marker system to distinguish Korean *Liriope platyphlla* from Chinese *Ophiopogon japonica* and Angelicae Gigantis Radix. The SNP (Single nucleotide polymorphism) in DNA was used to discriminate *Angelica gigas* from *Angelica acutiloba*. This technique will serve as a practical tool to distinguish Korean medicinal herbs from foreign medicinal herbs. Likewise, the molecular authentication system will be useful to legitimize the distribution of medicinal herbs in both domestic and foreign markets.

Development of functional foods, medicine and cosmetic materials

For the development of functional foods and cosmetic materials, an optimal condition of extrusion for increasing extraction of functional components from *Angelica gigas* Nakai was studied. As a result of statistical analysis of response surface methodology, the maximum extract contents of decursin and decursinol angelate were obtained when the seep screw was 61.33 rpm, feed rate was 35.67 kg/h, and water feed rate was 4.8 kg/h. Compared to the control, indicator components (decursin and decursinol angelate) of *A. gigas* increased by 16.6 per cent. Success was achieved in stabilization and property control of *A. gigas* extract by using nano-structured materials. It was also proven that encapsulation with nano-structures can enhance the intrinsic beneficial properties of *A. gigas* extract. Compared to the control group, the permeability of nano-emulsion into skins was higher in *in vivo* and *in vitro* tests. Veterinary antimicrobial agents were derived from medicinal plants. Bacteria possess a wide array of efflux proteins, and a number of antibiotic-resistant bacteria, including *Staphylococcus aureus*, pathogenic *Salmonella*, *Escherichia coli* and *Pseudomonas aeruginosa*, utilize these transporters (efflux pumps) as a part of their resistance strategy. Several medicinal plants showed repression of the efflux pump in antibiotic-resistant bacteria have been reported. From these results, it is expected that the development of functional foods and medicinal and cosmetic materials by using medicinal plants, will be highly beneficial.

Variety development

Development of new varieties and breeding efficiency technology in Panax ginseng

The main objective of *Panax ginseng* breeding is the development of varieties with good quality, high yield, disease tolerance, and the production stability for environmental factors such as

high temperature, and salt injury, etc. To achieve this, a study was conducted on registration of development variety, nurture of good line, collection and characteristics test of genetic resources, breeding efficiency technology, and the selection of adaptable varieties in each cultivation area. A high yielding variety 'Cheonryang' which is resistant to physiological stress, was registered by the Korea Seed and Variety Service in 2012. It was the first variety developed by national institute. 'Cheonryang' will be supplied to the farms, and will contribute greatly to good quality and stable production of ginseng. A total of 128 lines were collected to acquire native and imported germplasm, and evaluated the characteristics of approximately 1,000 genetic resources and selected 23 heat and salt-damage resistant 23 lines, and 12 disease-tolerant lines. Subsequently, a new high yielding and disease tolerant line 'Korea 1' was developed and assessed for adaptability of the new line in 5 regions. The early growth and weather environment change were investigated to select of adaptable varieties in each cultivation area. This preliminary data will help us in selection of adaptable varieties by agroclimatic zones. The results were also found encouraging in the field of efficiency breeding technology to develop good lines in early stages. This also helped in indentification of lines resistant to high temperature and disease infestation. In biotechnology, a method was developed for using DNA markers to differentiate between red ginseng extracts of *Panax ginseng* C.A. Meyer and *Panax quinquefolius* L., and therefore discriminated between imported ginseng and locally produced ginseng. Also, introduced was a 96 per cent labour saving automated control system for disease and insects, and selected a compound to prevent seed fruition without removing flower stalks.

Development and distribution of high quality and stress resistant crop varieties

The development of medicinal crop varieties was carried out during 1990-2000, with the goal of obtaining a standard variety. Especially for import substitution, new varieties of *Rehmannia glutinosa*, *Atractylodes* spp., and *Glycyrrhiza* spp. with high yield and disease resistance have been developed since 2000. *R. glutinosa*, a major medicinal crop, has been used as a restorative herbal medicine and health-promoting food since it is effective in increasing hematopoiesis and boosting the immune system. The annual demand for *R. glutinosa* in Chinese medicine is 1,300 tons but the availability of the material in Korea is less than 30 per cent, which is largely because of the frequent occurrence of root rot. Therefore, breeders have tried to develop new, high yielding *R. glutinosa* varieties that are disease resistant. 'Wongang' is a disease resistant and high yielding *R. glutinosa* cultivar which has small leaves and long, thick roots. Root yield of this cultivar was 18,250 kg/ha, which was an increase of 14 per cent compared to that of a check variety (Jihwang 1). *Atractylodes* spp. have long been cultivated in Korea and used to treat gastroenteric disorders. *Atractylodes* spp. were historically susceptible to root rot, and production of these plants in Korea was low. 'Dawon' is a high-trunk plant type and has many branches and thick roots. 'Dawon' is resistant to root rot and aphid incidence. Compared to the landrace check variety 'Pyeongchang', the root yield of 'Dawon' was 13,690 kg/ ha and yield increased by 77 per cent. The biggest problem in medicinal crop production is the supply of quality seeds. Seed supply systems has not yet been established for medicinal crops. Studies will be conducted on 22 crops, such as a *L. chinense*, with large cultivation area and 28 crops cultivated on a small area, such as *P. multiflorus*. Crops are classified on the basis of their cultivation area and habitat (e.g., plain, mountain) and each research group focuses on assigned crops. It is expected that this program will result in an increase in the penetration rate of new varieties from 10 per cent (current) to 37 per cent by 2015, and that farmers' income will increase up to Won 165 billion per year. A substitution effect on imports of Won 12.3 billion is also expected.

Cultivation practices

Development of good agricultural practices

The guidelines for good agricultural practices (GAP) of medicinal plants are intended to provide the basic principle for the producers (or managers) of medicinal plants. It applies to production and management of the medicinal plants without contamination, so as to supply high quality, hygienic and safe raw medicinal materials to the consumers.

Development of eco-friendly, safe cultivation technology for producing high quality herbal medicines

To secure public confidence in herbal medicines, it is necessary to produce and supply safe medicinal plants that are safe and uncontaminated by heavy metals and pesticide residues. However, the current system is insufficient to produce and distribute safe medicinal plants. About 50 types of medicinal plants are currently cultivated in Korea. However, as of 2010, good agricultural practices (GAP) cultivation guides for controlling production of high quality medicinal plants have provided guidelines for only 43 items, and only about 3.6 per cent of the total production is cultivated and processed according to these guidelines. Thus, there is an urgent need to prepare GAP guidelines for the remaining medicinal plants. In view of this, items of the GAP standard cultivation guide were expanded from 43 crops in 2010 to 50 crops in 2012, by preparing guidelines for *Salvia miltiorrhiza*, *Chaenomeles sinensis*, *Perilla frutescens*, *Artemisia argyi*, *Leonurus japonicus* and others. In addition, techniques for safe cultivation have been established for *S. miltiorrhiza*, of which the entire supply is imported. To determine the feasibility of establishing priority strategies for locally-grown medicinal crops, the current status of the local medicinal crop production system was assessed.

Dissemination of eco-friendly cultivation techniques for medicinal plants contributes to improved stability and increased farm income. Herbal medicines produced using eco-friendly practices can generally be sold at a higher price than those produced using conventional cultivation methods (e.g., 10% by GAP and more than 20% by organic cultivation). In addition, domestic production of *S. miltiorrhiza* (146 t/ -2010) can reduce the outflow of foreign currency by up to US $ 328,000. Environment-friendly organic cultivation techniques were developed on *Angelica gigas*, *Astragalus membranaceus*, *Lycium chinense* and 5 items, which consumers demanded safety and high-quality for domestic medicinal herbs. The current system is insufficient to produce and distribute safe medicinal plants.

Post-harvest management

This study was conducted to monitor the hazardous elements such as mycotoxins and benzopyrene found in storage and drying of some medicinal crops harvested in Korea. Contamination of moulds was observed in 63 samples (dried root of *Lycium chinense*, *Schisandra chinensis*, *Cnidium officinale* and *Paeonia lactiflora*) collected at storage facilities in Sangju, Cheongyang, Jecheon and Sancheong from April-June, 2010. The highest degree of fungi contamination was observed in natural drying and ambient temperature storage condition. But, there were no samples gathered above 10 ppb level (permissible level in herb medicines) of toxic compounds such as aflatoxin B1 and ochratoxin A. These results showed that the drying time and storage temperature are very important to reduce the contamination of fungi and mycotoxins for

producing safe herbal drug. Benzopyrene formation was also measured in the roots of *Rehmannia glutinosa* during drying period. The study showed that there were no samples recorded that reached above 5 ppb level (permissible level in herb medicines) and no correlations between benzopyrene formation and drying period in 60° which is the maximum degree in the normal drying of medicinal crops.

Pest and quality management

Concerted efforts were also made to develop quality control for herbal medicines to guarantee highly qualified medicinal herbs. Focused attention was given to the efforts on possible commercialization of the unknown food and medicinal materials of medicinal herbs and developing the needed post-harvest management to maintain their superior quality. A total of 376 methanol extracts of medicinal plants were assayed by disc-diffusion method *in vitro* for antifungal activity to various plant pathogens isolated from diseased seven species of medicinal crops such as *Rehmannia glutinosa*. HCRD-242, one out of 376 medicinal plant extracts tested showed strong antifungal activities against *Phoma* sp., *Alternaria* sp., and *Cylindrobasidium* sp. The investigation included manufacturing environment of domestic farm house and analysis beneo(a) pyrene contents of eight items of dried domestic herbal medicine including Rehmanniae Radix which have Benzo(a) pyrene detection history by KFDA in 2009. The range of beneo(a) pyrene contents all below 5 ppb were safe and could not find the problems of excessive heating in the manufacturing environment. Efforts were made to investigate the change of benzopyrene content depending on drying temperature and period. Benzopyrene contents was increased by temperature and period but there were no samples above 5 ppb by the maximum temperature of 190°C. These results suggested that the temperature during drying procedure of domestic medicinal plants might not be the main reason of benzopyrene overproduction. For this reason, artificial provocation test of benzopyrene by smoke exposure was carried out using straw and fossil fuels such as briquet. Artificial provocation test showed that benzopyrene was overproduced above 5 ppb in case of smoke contamination by incomplete combustion of fossil fuels.

Future Thrusts and Conclusion

Recently, production of horticultural and herbal industry continued to increase (Won 13.3 trillion in 2008 to Won 15.6 trillion in 2010) and the exportation of fresh horticultural and herbal crops also increased largely (US $ 592 million in 2008 to US $ 835 million in 2011). National Institute of Horticultural and Herbal Science (NIHHS) conducted research and development for breeding new varieties to meet consumers' demand and registered 179 new varieties during the last four years. NIHHS also supported the expansion of horticultural industry by diversification of exportation items, not only including new exportation items such as kimchi, flowers, strawberry and enoki mushroom but also increasing exportation of traditional items such as ginseng, oriental pear and apple.

For continuous development and competitiveness enhancement of horticultural and herbal industry, NIHHS conducted top priority projects such as (i) support for supply stabilization through the development of stable production technology for agricultural products, (ii) technology development in response to climate change, (iii) establishment of foundation and

development of model for urban agriculture, (iv) strengthening competitiveness and expanding export of horticultural and herbal industry, (v) expansion of agricultural product consumption by developing post-harvest management technologies, (vi) development and commercialization of crops for medicine and with health promoting compounds (vii) breeding and dissemination of domestic varieties to reduce royalty payment, (viii) development of horticultural and herbal varieties to meet consumers' demand, (iv) development and dissemination of energy saving technology in response to high oil price and (x) commercialization of R&D results. These projects need to be intensified and similar other projects need to be initiated.

In Korea, self-sufficiency of major crops has been in decline since natural disaster relief expenditure in agriculture due to abnormal weather rapidly increased (tenfold increase in 2012 compared to 2008) and production cost for major crops steadily increased. Therefore, it is required to develop technologies for stable production, crop damage reduction and management cost reduction in horticultural and herbal crops. The level of horticultural and herbal researches of Korea is now estimated to be top five in the world but it is still required to expand the investment on basic research and green technology. Especially in the field of horticulture, it is urgent to breed new varieties, improve crop quality, develop energy saving techniques and prepare climate change. In the field of herb, stable production system and value-added crop production are needed for ginseng, mushroom and medicinal plants.

By 2012, major countries have intensified global competition and expansion of well-being trend as in Korea to increase the consumption of safe agricultural products with functional substances. Therefore, consumers' demand for agricultural products with health promoting compounds and the need for plant factory technology have increased. In addition, consumers' demand for urban horticulture such as air cleaning plants has also increased. Uncertainty and variability of agricultural market have expanded due to abnormal weather and natural disaster. In view of the above, greater thrusts need to be given to address these issues effectively in order to promote the use of medicinal and aromatic plants in Korea.

Country Status Report on Medicinal and Aromatic Plants in Vietnam

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Introduction

Vietnam covers an area of about 333 thousand km^2 and extends about 1,600 km from 23°08'N to 6°50'N sandwiched between the Annamite mountain chain and the South China Sea and the country is bordered by China, Laos, and Cambodia. Three-quarters of the land area comprise hills and mountains and forests occupy about 40 per cent of the land. The climate is sub-tropical, tropical and humid, but conditions vary considerably due to the long spread of the country from north to south with wide range of topography. The greatest temperature variations are in northern and highland areas. The temperate agro-ecological environment in the northern lowlands is cool in winter months, but in highlands temperatures are low round the year. The tropical climate is witnessed in the north (in summer) but in the south and in the center, it persists through at the year. Therefore, there are many wild or cultivated plant species native in different climatic areas. Traditional medicines mainly based on medicinal and aromatic plants (MAP) have been used widely in all people groups. According to the survey data conducted in 2008 by the National Research Institute of Medicinal Plants, 3,870 vascular plant species, 90 per cent of which grow wildly in forests, have been used as popular remedies. However, the updated data showed that 4,470 species classified as MAP existed in Vietnam (2011). This indicates that the country is very rich in medicinal plant resources.

Area, Production and Productivity

Among the known MAP species existing in Vietnam, only 206 wild species are collected with about 12,000 tons/year and the other 136 wild species that are very seldom found, needed special conservation. On the other hand, there are 136 commercially cultivated species for traditional medicines and 308 are cultivated not only for medicinal but also for ornamental and spice purposes. Due to high competition with other foreign producers, the areas and number of MAP species is reduced recently. At present, there are only 53 species cultivated in small areas. Normally, they are grown in home gardens but some of them are cultivated as field crops either in sole cropping or intercropping systems and rarely as plantation crops.

Areas of MAP collection from forests

- Northern mountainous provinces: Ha giang (Districts of Quan Ba, Vi Xuyen, Bac Giang), Lao cai (districts of Bat Sat, Bao Thang, Van Ban, Sapa), Bac can (Cho Don, Na Ri), Lai chau (Sin Ho, Muong Te, Phong Tho), Son la (Song Ma, Muong La), Hoa Binh (Lac Soc, Lac Thuy), Cao bang, Quang Ninh (Ba Che, Van Don).
- Provinces of the northern center: Thanh hoa, Nghe an, Ha Tinh, Quang Binh, Thua Thien Hue;
- Provinces of the southern center: Quang nam, Quang ngai, Phu yen;
- Provinces of the central high land: Kon Tum, Gia lai, Dac lac, Dac nong, Lam dong.

In all, 62 species of MAP are having high demands and are be collected from the forests and some of them are listed in Table 1.

Table 1. Important MAP species in Vietnam

Scientific name	Vietnamese name	Scientific name	Vietnamese name
Desmodium triangulare	Ba chẽ	*Uncaria rhynchophylla*	Câu đằng
Eurycoma longifolia	Bách bệnh	*Rhizoma Cibotii*	Cẩu tích
Stemona tuberosa	Bách bộ	*Schefflera octophylla*	Chân chim-ngũ gia bì
Hedyotis diffusa	Bạch hoa xà thiệt thảo	*Ampelopsis cantoniensis*	Chè dây
Tuberstephaniae glabrae	Bình vôi	*Jasminum subtriplinerve*	Chè vằng
Acorus gramineus	Nhân trần	*Terminalia chebula*	Chiêu liêu-Kha tử
Rhizoma drynariae	Bổ cốt toái	*Kaempferia galanga*	Địa liền
Hyperricum patulum	Ban tròn	*Cassia tora*	Thảo quyết minh
Solanum hainanense	Cà gai leo	*Smilax glabra*	Thổ Phục Linh
Milletia speciosa	Cát sâm		

The total estimated demand of MAP is about 60,000 tons annually, of which 20,000 tons are used in a pharmaceutial industry, the same amount is used for popular remedies and about 30 per cent of that is exported. However, the domestic production is only 30,000 tons of which 12,000 tons are collected from the wild. The rest are imported, mainly from China.

Areas of MAP cultivation

- The Northern Delta Region with monsoon climate consists of the medicinal plants cultivating areas such as Hanoi (districts of Thanh Tri, Thuong Tin), Hung Yen (districts of Van Giang, Chau Giang), Hai Duong (Gia Loc and Tu Ky).
- The northern midland region with subtropical monsoon climate and cold winter, including the medicinal plants cultivating points in the provinces of Hoa Binh (Mai Chau districts), Tuyen Quang (Chiem Hoa), Vinh Phuc (Tam Duong), Bac Giang (Son Dong), Ha Giang (Pho Bang, Quan Ba).

- The northern mountainous regions with sub-tropical monsoon climate with rainy summer and very cold winter, including district of Moc Chau (Son La province), Mu Cang Trai (Yen Bai), Mau Son (Lang Son), Thong Nong, Ha Quang (Cao Bang), Bac Ha (Lao Cai).
- The high mountainous region with temperate climate, including district of Sa Pa (Lao Cai), Sin Ho (Lai Chau), Tumorong (Kon Tum), Tra My (Quang Nam), Da Lat (Lam Dong)
- The coastal central region having tropical monsoon climate with rain in autumn-winter including the districts of Nga Son (Thanh Hoa), Tuy Hoa (Phu Yen), Long Thanh (Dong Nai)
- Central high land region with a tropical monsoon climate, cool and rainy summer including the districts of Eukao (Dak Lak), Dac Nong (Dak Nong), Lam Ha, Duc Trong (Lam Dong).

In order to meet the demands, local and some introduced MAP species have been cultivated in different scales. Each year, there are about hundreds to thounsands tons of products for domestic and foreign markets consisting of: Actiso (*Cynara scolymus*), Ba kích (*Morinda officinalis stow*), Bạc hà (*Mentha* ssp), Bạch chỉ (*Angelica dahurica*), Bạch truật (*Atractylodes macrocephala*), Nhân trần (*Acorus gramineus*), Bụp dấm (*Hibiscus subdariffla*), Cúc hoa (*Chrysanthemum indicum*), Diệp hạ châu (*Phyllanthus urinaria*), Địa liền (*Kaempferia galangal*), Đỗ trọng (*Eucommia ulmoides*), Đương quy (*Angelica sinensis*), Đinh lăng (*Panax fruticosum*), Gừng (*Zingiber officinale*), Gấc (*Momordica cochinchinensis*), Kim tiền thảo (*Herba Jinqiancao*), Lô hội (*Aloe barbadensis*), Mã đề (*Plantago major*), Sâm ngọc linh (*Panax vietnamensis*), Thanh cao hoa vàng (*Artemisia annua*), Thảo quả (*Amomum tsaoko*), Trinh nữ hoàng cung (*Crinum latifolium*), Y dĩ (*Semen coicis*).

Major Uses

Medicinal and aromatic plants have played a significant role in traditional medicines and the socio-culture of Vietnamese people, with the population of 90 millions (in 2013), and about more than 70 per cent residing in rural areas. A large number of ethnic minority groups scattered in the mountainous and highland areas do not have access to modern medicines. Not only people living in rural areas but also the people in high-income group still rely on traditional systems of medicine to meet their healthcare needs, resulting in increases in the demand of MAP and their products. Besides, Vietnam possesses an age-old traditional system of medicine being transferred from generation to generation. Therefore, the use of traditional medicines is rooted in the society. Most medicinal plant species utilized for traditional medicine in Vietnam are sourced from the wild.

According to the Ministry of Health, there are thousands of hospitals, institutions and companies involving with processing, compound extraction and remedies based on MAP. Traditionally medicinal hospitals are almost available in every city or province. Until the end of 2008, the number of hospitals and companies dealing with MAP were listed as follows: 51 public hospitals, 2 private hospitals, 10,740 clinics, 501 nursing and function rehabilitation offices, and thousands of business and production facilities. Among 8,487 pharmaceutical products registered by the Ministry of Health, there were 1,870 products made from MAP, accounting

for 22 per cent (2007). Traditional medicines are very potential, particularly for products that treat chronic diseases, functional impairment, and treatment of diseases about liver, diabetes, high blood pressure. Because of improved living condition and government policy, the demand for traditional medicines and functional foods processed from MAP has increased dramatically. So far, traditional medicines including domestic and import productions meet only 20 per cent of the demand, indicating that Vietnam has a very good potential market for MAP. From the MAP, active compounds, botanical oils and traditional medicines have been made and are listed below:

- Extraction of rutin from *Sophora japonica*
- Extraction of Berberin from *Coscinium fenestratum*, *Berberis* spp., *Mahonia* spp., *Coptis* spp.
- Extraction of Balmatin from *Fibraurea tinctoria* and *Fibraurea resisa*
- Extraction of D-Strophantin from *Strophanthus divaricatus*
- Extraction of Rotundin from *Stephania* spp.
- Extraction of Mangiferin from *Mangifera indica*
- Extraction of Strychnine and Brucine from *Strychnos* spp.
- Extraction of Quinine from *Cinchona* spp.
- Extraction of Scopolamine and Hyoscyamine from *Datura* spp.
- Extraction of Beta-Caroten and Lycopen from *Momordica cochinchinensis*
- Extraction of Curcuminoid from *Curcuma longa*
- Extraction of Steviosid from *Stevia rebaudiana*

There are number of institutions and pharmaceutical companies that make special efforts to research and produce many kinds of medicines and functional foods. Vietnam National Institute of Burns produced Eupolin from *Eupatorium odoratum*. The medicine has been used for treatment of burn diseases. Vietnam Military Medicinal Academy produced injection medicine of rotundin sulfat from *Stephania* spp. Phytopharma company released the capsules from *Crinum latifolium* for treatment of benign prostatic hyperplasia (BPH). Worms are treated by embin produced from *Embelia scanden* and stomach diseases cured by ampelop extracted from *Ampelopsis cantonensis* in Traphaco company. The other traditional medicines made from MAP have been produced such as Artesunat (for treatment of malaria), Agerhinin from *Ageratum conyzoides*, Ligustan from *Ligusticum wallichii*.

Significant Achievements

Germplasm collection, evaluation and conservation

In the list of 206 species of MAP being collected from the wild, most of them are found in forests. However, 62 species mentioned above are threatened because of overexploitation and utilization in large quantities annually, some species are at risk and should not be harvested. Passport data of 250 species have been developed. Preliminary evaluation in term of phenotype, agronomic characters and active medicinal compounds have been undertaken in 630 species

out of 730 conserved species. To conserve and develop the existing resources of MAP to ensure sustainable exploitation, the Government has provided funding support for germplasm conservation projects including *in situ* and *ex situ*.

In 1996, the first red list of MAP consisting of 128 species classified in 59 botanical families was issued. The second list published in 2001 had 114 species in 53 families, and the third published in 2007 included 144 species in 58 families of which there were 18 species in the critically endangered group, 57 species in the endangered group, and 69 species in the vulnerable group. Based on the list, special attention has been given to conserve these species on priority in national parks. *Ex situ* conservation has been done for 730 species, including 86 species in the red list. Besides, the threatened species have been conserved *in situ*. Seeds of 120 species are stored for short-term under low temperature condition. In the national genebank, there are 12 precious and rare species conserved *in vitro*.

Varietal development

Not much breeding work has been done to develop high yielding varieties of medicinal and aromatic plants. Studies on genetics, breeding, and biotechnology for MAP have also not been done.

Constraints and Opportunities

Constraints

Increasing demand for traditional medicine has important implications for the conservation of the many species of flora upon which traditional remedies are largely based. There is growing evidence to suggest that many of these have become more difficult to obtain from the wild, and a number of them are listed as species of conservation significance. Additionally, increasing use of traditional medicines in China has seen vast quantities of plants sourced from Vietnam transported to the Chinese market, putting further strain on these plant populations. Despite their importance to health and livelihoods, relatively little investment has been made in assessing the conservation status of most medicinal plant species or in developing more sustainable harvest and trade practices. Many MAP are wildly collected and associated with natural forests. However, natural forest areas reduced sharply, causing wild populations narrowed and some wild species were being overexploited or threatened. In order to protect overexploited MAP while improving the limited and unstable income of large number of local collectors, polices and decrees concerning with forest protection and development are lacking.

Opportunities

There are tremendous opportunities for promotion of MAP in Vietnam through better strategy for forestry development and development of MAP in protected forests, specific forests and production forests. The Government of Vietnam during 2006-2020; and the new cultivation project for 5 million hectares of forests will provide a great opportunity for stable production and MAP associated with forests in the coming years. Protected forests in the country are about 5.68 million ha including 5.28 million ha watershed forests, 0.18 million ha of protected

forests as breakwater, 0.15 million hectares for wind and sand breaks, and 70,000 ha for environmental protection in urban and industrial zones. MAP are known to play critical role on an area of 5.28 million ha of the watershed forests. It is necessary to keep up forest cover with all measures. MAP with high economic efficiency and suitability with natural conditions are selected for conservation and cultivation. National specific forests have 2.19 million ha with the area of national parks, nature reservation, and protected biodiversity areas. Only with the exception of the core zone of national parks, MAP should be brought to the rest of these forests in order to develop *in situ* conservation of native species and add genetic resources to make biological diversity associated with medicinal plant genetic resources conservation. Production forests are planned in about 8.4 million ha area of which 3.63 million ha is natural forests, 4.15 million ha is planted and 0. 62 million ha of recovered forest towards agro-forestry production. These areas can be focused on combining between forest planting and MAP cultivation on a large scale. MAP normally are annual crops and have shorter life cycles, occupying in the initial plantation stage of forest plants. Many medicinal plant species require a shading condition under canopy of forests.

Future Thrusts

For the conservation and development of MAP associated with improving of living standards for households, future thrusts need to be given to the following aspects:

- Development of Governmental Master Plan to develop MAP associated with forestry development strategy.
- Assessment of natural resources and planning for collection and conservation of the special MAP species to ensure their exploitation, sustainable use and management of genetic resources effectively.
- Developing cultivation technology suitable for MAP. The production areas can be located in forests and need to be managed according to good agricultural practices (GAP).
- Organizing training courses for forestry companies, forestry business enterprises, and households to improve their knowledge of planting, conservation, harvesting and processing to ensure the quality of medicinal and aromatic materials.
- Promotion interdisciplinary collaboration between healthcare and forestry for exploitation, utilization and management of natural resources of MAP.
- Develop policies appropriate for the development of MAP associated with the national strategy of forest development such as supporting for infrastructure, tax breaks, technical assistance and certified plating materials.
- Strengthening collaboration between countries in the region for germplasm exchange and conservation by suitable approaches (*ex situ*, *in situ*), especially for species in the red list.
- Organizing international workshops and training courses for exchange of experiences in terms of breeding, germplasm exchange, and processing and value addition to improve the quality of MAP.

Country Status Report on Medicinal and Aromatic Plants in Myanmar

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Introduction

Myanmar is the largest country in Southeast Asia with an area of 676,577 km^2. It shares its border with Bangladesh, India and the Bay of Bengal in the West, China in the Northeast, Lao PDR and Thailand in the East and the Andaman Sea to the South. Myanmar's climate is greatly influenced by the monsoon, leading to three distinct seasons namely, hot, rainy and cold. Temperature over the whole country varies widely, from less than 0°C in the northern highlands to over 40°C in the central dry zone. Annual rainfall ranges from 500 mm in central to 5,000 mm in the coastal region. The Union of Myanmar is topographically divided into four main regions; i) the western mountain ranges comprising the Rakhine, Chin and Kachin hills with extensive forest, ii) the Shan plateau region in the east with tropical rain forest, mixed deciduous forests and pine forest, iii) the central region which includes the fertile agricultural valleys of the Ayeyawady, Chindwin and Sittaung Rivers and the hills of the Bago Yoma which bear the finest teak forests of the country, and iv) the Ayeyarwaddy delta and coastal region which includes coastal areas.

The country is rich in forest resources with 47 per cent of the total area under forest cover. Myanmar possesses a great extent of forest biological diversity; marine biodiversity in the coastal areas, coastal and inland mangrove, tropical evergreen forest in the south, moist deciduous, dry deciduous forest, dry and sub-humid land in the central, snow-capped mountains in the far north.

Traditional medicine systems

The rural communities of Myanmar have been using traditional medicines since ancient times. Myanmar traditional medicine system is based on Buddhist philosophy and the theories of Ayurveda. It has developed through the long history of the country with the contribution of several famous physicians since the times of the Myanmar kings. Allopathic medicines were promoted over traditional medicine, from the beginning of the colonial period (1885) in Myanmar. Traditional medicine regained prominence due to the shortage of allopathic medicines during the World War II. Since then, it has been encouraged and people now rely more on these rather than on modern medicine for healthcare (WHO, 2001).

The Government has been giving priority to the development of traditional medicine for public healthcare services. Various development programs on the conservation of medicinal plants, supporting the indigenous medicine practitioners, encouraging research and developmental activities have been implemented by the Government. The Ministry of Health established the Institute of Indigenous Medicine in 1976, the Department of Traditional Medicine in 1989 and the University of Traditional Medicine in 2001 for promotion, preservation and training of traditional medicine in the country. Attempts have been made to integrate traditional and modern medicines in combating health problems and diseases such as diabetes, hypertension, malaria and tuberculosis (Nyunt, 2002).

Medicinal and aromatic plant resources

About 7,000 plant species have been recorded so far in Myanmar with 1,071 species as endemic. Various plants have been used as sources of indigenous medicines by the people. (Sukhdev *et al.,* 2006). In upper Myanmar, local climate conditions, ecological and cultural specificities also provide the advantage and special niche, and opportunities for renewable, sustainable green economy by means of non timber forestry produce **(**NTFPs) including medicinal and aromatic plants resources. The plants such as *Aquilaria agallocha* Roxb., *Hesperethusa crenulata* (Roxb.) *Mansonia gagei* Drumm., M. Roem., *Premna integrifolia* L., *Pterocarpus santalinus* L. f. and *Santalum album* L. are found commonly and used in incense sticks, fragrances, production of cosmetics and medicines. The demand for medicinal plants and herbal raw materials has increased as a result of industrial growth of indigenous medicines as well as the pharmaceutical industries. However, there is limited cultivation of medicinal plants in the country with the majority of them being collected from the forests.

Research and development activities

Various programs on the establishment of herbal gardens for conservation and cultivation of medicinal plants have been implemented and research is aimed at inventing new drugs from plants. Many institutions and universities are engaged in research on botanical, chemical and medicinal aspects of 88 native medicinal plants. National level conferences on traditional medicine are being organized in different parts of the country (Anonymous, 2002). In order to produce raw material for drug manufacturing factories, rare and potent medicinal plants have been cultivated on about 81 hectares at nine herbal gardens established in different parts of the country (Anonymous, 2000). Some research work for the development of new drugs from plants has also been carried out by the Department of Medical Research of the Ministry of Health.

Area, Production and Productivity

Over 70 per cent of population in Myanmar is living in rural area. Overexploitation of medicinal plants for income generation as well as domestic use, has seriously depleted MAP resources alongwith loss of habitats, resulting in a shortage of some particular medicinal plant species, and so adversely affecting sustainability in the future. Indeed, the market and public demand has been increasing, leading to the risk of the extinction or loss of genetic diversity of medicinal plant species.

Traditional medicines have been manufactured by both public and private sectors and the Department of Traditional Medicine is responsible for manufacturing in the public sector and

owns two pharmaceutical factories and yearly production is 10,000 kg and medicines are produced according to the national formula. The private traditional medicine industries are also developing and conducting mass production of potent medicine according to the good manufacturing practices (GMP) standards.

Herbal gardens: With the aim of perpetuation of medicinal plant species, sustainable development of herbal medicines and provision of quality raw materials for public and private pharmaceutical factories, the Department of Traditional Medicine has established one garden after another for the cultivation of medicinal herbs. Nine herbal gardens have been established in area of 120 hectares in different regions of the country and established nurseries for six major diseases such as diabetes, hypertension, tuberculosis, malaria, diarrhea and dysentery.

National herbal park: The national herbal park was opened in January 2007. It has an area of 196.4 acres and has about 500 different species of medicinal plants collected and cultivated from 14 States and Divisions of Myanmar.

Traditional medicine museums: There are three traditional medicine (TM) museums run by the Department: one in University of Traditional Medicine, Mandalay and two in National Herbal Park, Nay Pyi Taw. People can study the roots and current situation of Myanmar traditional medicine in one sitting. The raw materials from animal, plant, mineral and aquatic sources used in TM drug formulations are also displayed colorfully.

Organic herbal farm: It is located in Pyin Oo Lwin, Mandalay and produces only organic herbs for FAME Pharmaceuticals which is the largest manufacture of Natural and Organic Medicine in Myanmar.

Major Uses

Limonia crenulata Roxb, Chinese box tree (English), known as thanakha is famous traditional cosmetics in Myanmar. Bark is used to produce local cosmetic which is used by ladies, children and men to protect the skin. It is believed to condition the skin and protects it from sunburn. Leaves, fruits and roots can be used to produce traditional medicines but its uses depend on types of thanakha. The medicinal and aromatic plants and their uses are shown in Table 1.

Table 1. Medicinal and aromatic plants and their uses in Myanmar

Botanical name	Family	Plant part(s)	Uses
Acacia arabica (Lam.) Willd	Fabaceae	Bark	Astringent, in diarrhea
Adina cordifolia (Roxb.) Hook. f. ex Brandis	Rubiaceae	Bark	Tonic, febrifuge, antiseptic
Alpinia galanga (L.) Sw.	Zingiberaceae	Root	Aromatic
Aquilaria agallocha Roxb. *Aquilaria malaccensis*	Thymelaeaceae	Wood	Aromatic, stimulant, aphrodisiac, tonic, diuretic

Contd...

Table 1 (contd...)

Botanical name	Family	Plant part(s)	Uses
Aquilaria aganlocha		Flower and leaves	Agar flower tea, agar flower and dried leaves tea, agar attar, agar honey, agar pollen,
		Resin	Perfumery - aphrodisiac, agar essential oil
Butea frondosa Roxb. ex Willd.,nom. illeg.	Fabaceae	Flower	Astringent
Cassia angustifolia Vahl	Fabaceae	Leaf	Laxative
Citrus medica L.	Rutaceae	Peel	Scurvy
Curcuma longa L.	Zingiberaceae	Rhizome	Anti-inflammatory
Cyperus rotundus L.	Cyperaceae	Tubers	Liver tonic, digestive tonic
Cateya lutes Royle		Aroma rhizome	Spice and medicine
Dactylorhiza hatagire		emperate, terrestrial, orchid underground stem	Tonic like Ginseng.
		Rhizome	Tonic traditional Chinese medicine, Tibetan medicine
Eclipta alba (L.) Hassk	Asteraceae	Whole plant	Antihepatotoxic
Emblica officinalis Gaertn.	Euphorbiaceae	Fruit	Antioxidant, tonic
Gaultheria semi – infera (CB.CI)			Wintergreen oil
Litsea glutinosa (Lour.) C. B. Rob.	Lauraceae	Leaf, bark	Gastro-intestinal disorders
Listea cabeba		pepper-like fruits	Cubeba oil, deodorant, perfumery
Nigella sativa L.	Ranunculaceae	Seed	Anthelmintic, carminative
Phyllanthus amarus Schumach. and *Thonn.*	Euphorbiaceae	Whole plant	Jaundice, gonorrhea, diabetes
Piper betel (Linn.)	Piperaceae	Leaf	Antiseptic, poultice for boils
Pterocarpus santalinus L. f.	Fabaceae	Bark	Astringent, in diarrhea
Rauvolfia serpentina Benth. et Kurz.	Apocynaceae	Root	Hypotensive, sedative
Santalum album L.	Santalaceae	Wood	Antiseptic
Styrax benzoides Crab commercially known as Benzoin(or) Lawpan		Resin	Fragrence

Significant Achievements

Germplasm collection, characterization conservation and documentation

In situ conservation of mangoes and medicinal plants was initiated in 1980 by Department of Agricultural Research (DAR) which is responsible for collecting and conserving PGR. Systematic PGR management began after establishment of the Seed Bank in 1987 with the support of the Japan International Cooperation Agency (JICA). PGR management system adopted the following steps: i) exploration, ii) classification, iii) collection, iv) multiplication, v) rejuvenation, vi) characterization, vii) evaluation, viii) conservation, ix) data management, and x) utilization. The Seed Bank conserves crop species in line with economic policies, therefore, conservation of rice, oilseed crops, and food legumes are given priority. (Thaingi Swe, 2007) The Vegetables and Fruits Research and Development Centre (VFRDC) conserves horticulture species including medicinal orchids.

The forest department has been conserving many forest species including the species of social and economic importance through natural regeneration. Genetic materials such as teak, hardwood and some medicinal plants are conserved in natural communities, following landraces in their areas of cultivation. New plantations are formed particularity with the intention of targeting to save plant materials of yet unknown genetic potential of wild relatives. To sustain the potential for improvement of genetic resources, conservation programs are directed towards long-term conservation either *in situ* or *ex situ*.

Ex situ conservation is carried out sporadically by the forest department dealing specially with forest species. While effects are being put in the *ex situ* conservation by the MAS endeavoring as much as possible mainly in evaluation, characterization, preservation and documentation of plant genetic resources. Agarwood Societies are participating in *in situ* conservation of old trees and 70 year old agar tree are kept as reserved for producing seed for new plantation.

Variety development

Very little work has been done on variety development in medicinal and aromatic plants in Myanmar. Research for identification and development of varieties in medicinal and aromatic plants variety is urgently needed.

Cultivation practices

Unlike major crops such as rice, oilseed crops, limited research and development work has been done on cultivation of medicinal plants of the country and proper cultivation methods are not in place. Thanakha plants are regenerated in two ways, natural and artificial regenerations. Natural regeneration of its seed is generally good, mostly around the mother tree in the rainy season and also dispersed by wind, water and birds. But now, artificial regeneration of it is very common because it becomes marketable as non wood forest products (NWFP). So, the farmlands and some non-cultivated slow growth lands for other cash crops such as groundnuts and other crops grown in dry zone have been transformed into the proper lands of thanakha plants as commercial cultivation.

Tonic medicine, antioxidant, anti-malaria, anti-ageing, antitoxin, medicine of Ayuveda, Traditional Chinese medicine and Traditional Tibetan medicinal plant resources have been cultivated and preserved in the nature forest or in the style of home garden medicinal farm. Nine herbal gardens have been established in area of 120 hectares in different regions of the country.

The following are non-timber forestry produce of upper and northern parts of Myanmar:

Aquilaria aganlocha: It is naturally existing but now 2 million young trees have been planted in ecologically-niche area in the style of community forestry in Northern Myanmar.

Gaultheria semi-infera: It is found in naturally existing flora of Northern Myanmar at the mountain ranges of Myanma's Himalaya. Community forest in Seinlone, Nonmom and Sadone has started planting the *Gaultheria* for commercial sale. Myanmar wintergreen oil was found to be the best in the world. Community plantations have been established at Puta O - That essential oil will be exported to foreign market.

Styrax benzoides Crab: Commercially known as Benzoin (or) Lawpan is existing in the Myanmar section of Himalaya .Community Forest of Sadone, Seinlone and N'gaw Chang protected this species under *in situ* condition with 20,000 trees existing in nature. A nursery for 100,000 plants has been established. A 10,000 acre plantation owned by indigenous people was established in 2012. Resin tapping can be conducted 7 years after cultivation.

Cubeba oil: This species is grown mainly at the northern Myanmar section of Himalaya region. Local people are used to distilling the oil from pepper-like fruits. About 30-50 tons of cubeba oil are sold to China. Commercial scale cultivation has also commenced at Sadone.

Disease and pest management

At present, there is no information available on disease and pest management aspects of medicinal and aromatic plants in Myanmar.

Production of quality seed and planting material

There are serious limitations in the availability of quality seed and planting materials of high yielding varieties of medicinal and aromatic plants. The efforts in this direction are also not being made to the required extent.

Primary processing, value addition and product development

Only private sector is involved in processing, value addition and product development. Value addition is limited due to lack of appropriate technologies and support structures. Among famous brands of thanakha, the products "Shwe Pyi Nan" Company are being exported to Thailand and the Philippines and the company has won 2008 Global Excellence Awards and 2009 People's Choice Award presented in the Philippines. These products are also seeking export market to South Korea. Small and medium enterprises (SME) are involved in value addition like cosmetics, royal jelly, bee pollens, noni and product development for local markets and their own consumption.

Marketing, commercialization and trade

Trade information is greatly understated because of the illegal trade activities. All the medicinal items are listed under essential import items as the local production of medicinal herbs is very low and the domestic pharmaceutical production falls short of internal demand. The medicinal plants and pharmaceutical drugs are largely imported from neighboring countries such as Bangladesh, China, India and Thailand. Local manufacturers cater to the needs of domestic markets with some export of the traditional drugs to neighboring countries such as China and Thailand but the trade is largely illegal and thus unrecorded. (Sukhdev *et al.*, 2006)

The harvest of agarwood from all Aquilaria spp. is prohibited under 'The Protection of Wild Life and Wild Plants and Conservation of Natural Areas Law, 1994'. According to Indian traders, agarwood from Myanmar is in high demand owing to its high quality and, despite the ban, is obtained relatively easily via large-scale smuggling into Manipur, particularly through the district of Churachandpur. Indian processing units in Nagaland and Manipur are said by traders to be supplied partly from Myanmar (the remainder of supplies being from Bangladesh), because of a lack of local sources in India. Myanmar became a Party to CITES in November 1997. CITES annual report data do not show any trade in agarwood involving Myanmar.

In Myanmar, snakeroot (*Rauvolfia serpentina*) is used in indigenous medicines, to treat hypertension, as a sedative, and for treatment of intestinal disorders (Aung Din, 2005). It is collected and traded mainly for domestic use in indigenous medicines. Local people collect the species and sell it to small traders in the nearest towns, who distribute the plants to major traders in big cities such as Yangon and Mandalay (Zaw, 2005). Wholesalers also have agents who collect the species in local areas, possibly buying from village collectors (Aung Din, 2005). Some local collectors sell directly to cottage medicine industries. Harvest within Myanmar is primarily to meet domestic demand, although CITES trade data and other information indicate that harvest for export is also undertaken. India's Customs data also show the import into India of significant quantities of "Serpentina roots" from 1999-2000 to 2003-2004, with over 200 tons of roots imported during this period. Noting high demand from pharmaceutical industries, particularly from traditional Chinese medicine, and Myanmar's long common borders with China, Thailand and India, the Director of Myanmar's CITES Scientific Authority believes that illegal trade may occur.

Constraints and Opportunities

Traditional medicine

Traditional medicine has been used for a long time without standardization and quality control measures. The lack of appropriate post harvest technologies, including collection, harvesting, drying, packaging and storage, standards for quality and safety of traditional drugs, skilled personnel, raw material, equipment, technology for drug manufacture and research are the major constraints in the commercial development of this sector. (Sukhdev *et al.*, 2006)

Now Myanmar Government has been giving priority to the development of traditional medicine for public healthcare services as well as encouraging on the conservation of medicinal plants, research and developmental activities.

Modern medicine

Modern medicines are more effective but consequence of side effects are dangerous. The modern medicines are also derived from MAP species.

Approaches for Meeting Emerging Challenges

At present, some of these invaluable plant species in Myanmar, as in other countries, are unfortunately dwindling due to over collection, overexploitation and loss of habitats, the increasing expansion activities, and thus reducing the options for the future. Some of these species became quite scarce. Approaches suggested for meeting the emerging challenges are:

- Strengthen the cultivation of medicinal and aromatic plants. About 20 kinds of ingredients for traditional medicines are imported from China, India, Malaysia, etc.
- Enhance support for research and development on conservation, reproduction, cultivation, breeding and evaluation of medicinal plants.
- Get more information and technology support for commercial cultivation, research and development
- Develop gene bank for collection and conservation of medicinal plants
- Provide education and training to collectors, growers and traditional medicine practitioners
- Develop real statistics and database for production, utilization of MAP species.
- Promote public awareness about the importance and use of MAP species for healthcare
- Cooperate and coordination of public and private sectors, International organization for utilization, production of MAP exportation

Future Thrusts

Greater thrusts need to be given in future for the promotion of medicinal and aromatic plants in Myanmar

- Improving the knowledge and skill of experts on MAP species and herbal medicine.
- Increasing production of public manufacturing plant for traditional medicine by new technology and newer medicine.
- Enhancing sustainability to access the quality, safety and efficacy of traditional medicine by public and private sector.
- Continuous cooperation and coordination with national and international stakeholders and sharing knowledge and information with networking system.

Conclusion

To achieve the quality, safety, efficacy of traditional medicine, quality management aspect

needs to be addressed through adoption of good agricultural practices (GAP), good collection practices (GCP), good storage practices (GSP), good manufacturing practices (GMP), and good laboratory practices (GLP) for MAP species. The networking system at the regional and international level that can facilitate to share knowledge and technical knowhow should be developed.

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Country Status Report on Medicinal and Aromatic Plants in Thailand

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Trade of MAP in Thailand

• Traditional healthcare and export	300,000 mb.
• Cosmetics	140,000 mb.
• Supplementary foods	80,000 mb.
• Herbs	10,000 mb.
• Spa and others	70,000 mb.

Road Map of MAP Work in Thailand (2014-2019)

- Promoting MAP products for the use in national drug industry and export
- Standardization of Thai MAP products using Thai GAP
- Conservation of Thai MAP plant genetic resources.

Promising Thai Herbs and Products

- Turmeric
- Phlai (Cassumunar ginger)
- Krachai-Dam (Kaempferia parviflora Wall)
- Asiatic pennywort
- Herbal compressed balls

Medicinal Plants Research in DOA

- Genetic variation, conservation, improvement
- Production technology
- Production control

MAPs Production

Objectives

- High yields & standardization of active ingredient levels
- Addressing problems from pests and diseases
- No Toxicity from insecticides and metal substances

Results : MAP Varieties

Turmeric (*Curcuma longa* L.) 2 vars.

Trang 84-2

Trang 1

กระชายดำ Krachai-Dam 2 vars.

DOA : Promising Herbs

ไพล (Phlai)
Cassumunar Ginger

ฟ้าทะลายโจร (crest)

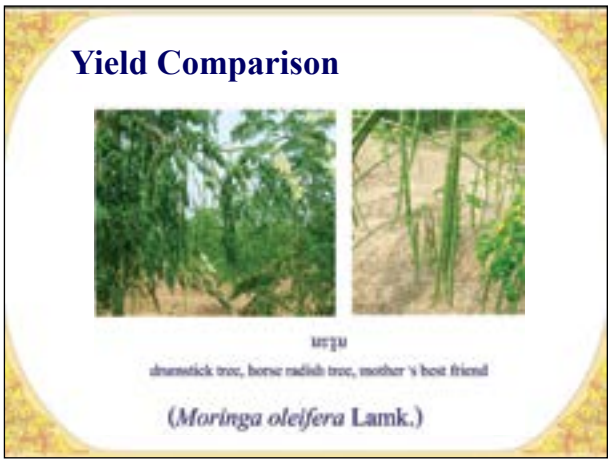
บัวบก
Asiatic pennywort

Andrographis paniculata (Burm. f.) Nees

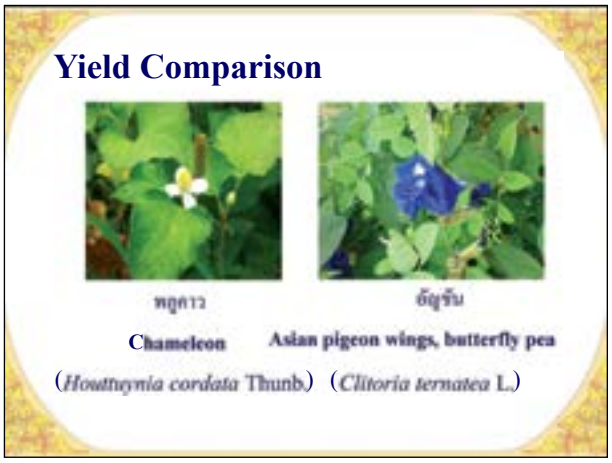

ปัญจขันธ์
Gynostemma pentaphyllum (Thunb.) Makino
ผักข้าว
Spiny bitter gourd
(Lour.) Spreng.


Yield Comparison
ไกรยุทธ์ภาพา
Artemesia annua L.
มะขามป้อม
Phyllanthus emblica L.


ปัญจขันธ์
Gynostemma pentaphyllum (Thunb.) Makino
พันธุ์สิบสองปันนา
cv. Sipsongpanna
พันธุ์อ่างขาง
cv. Angkhang
พันธุ์พื้นเมือง
cv. Local


Yield Comparison
มะรุม
drumstick tree, horse radish tree, mother 's best friend
(Moringa oleifera Lamk.)


ดีปลี
Java long pepper
(Piper retrofractum Vahl)
รางจืด
(Thunbergia laurifolia Lindl.)


Yield Comparison
หูกวาง
Chameleon
(Houttuynia cordata Thunb)
อัญชัน
Asian pigeon wings, butterfly pea
(Clitoria ternatea L.)

Production Technology

Research on :

- Species/varieties/promising lines
- Spacing/shading/mulching irrigation/ fertilization/ pest and disease control
- Post-harvest and processing technology

Research on :

- Quality control and good agricultural practices (Thai Herb GAP), no toxins in MAP products
- *GAP registered production areas = 3,000 rais (480 ha)*

Gynostemma pentaphyllum (Thunb.) Makino

Cultivation of *Andrographis paniculata* (Burm. f.) Nees

Conservation

Collection & Conservation by DOA

DOA Thailand collected and conserved herbs and spicy plants of over 1,500 species/varieties in 5 areas in north, northeastern and south research satellite centers.

White Kwao Keur

Pueraria candollei Grah. ex Benth. var. *mirifica*

(A. Shaw and Suvattabandhu) Niyomdham

กวาวเครือขาว

Pueraria candollei Grah. ex Benth. var. *mirifica*

(A. Shaw and Suvattabandhu) Niyomdham

Red Kwao Keur *(Butea superba* Roxb.)


ฟักข้าว
Momordica cochinchinensis (Lour.) Spreng.


ฟักข้าว (Baby jackfruit, Spiny bitter gourd, Cochinchin gourd)
Momordica cochinchinensis (Lour.) Spreng.


ฟักข้าว (Baby jackfruit, Spiny bitter gourd, Cochinchin gourd)
Momordica cochinchinensis (Lour.) Spreng.


And others (MAPs)


Thank you

Annexure I

Opening Address

Hiroyuki Konuma
Assistant Director-General and
FAO Regional Representative for Asia and the Pacific

Dear Dr. Paroda, Executive Secretary, APAARI, respected resource persons, participants and colleagues, very good morning to all !

It is a great pleasure for me to be here to open the Expert Consultation on Promotion of Medicinal and Aromatic Plants in Asia and the Pacific region jointly organized by APAARI and FAO. First of all, I would like to thank APAARI to arrange this important event in partnership with FAO. I would also like to express my sincere gratitude to all participants and governments of participating countries for sending their delegates/experts to attend this consultation and including the poor farmers and villagers living in mountain areas. I am very glad to open this Expert Consultation which is being organized today after many years of dream, and despite security difficulties.

As we all know, medicinal and aromatic plants have traditionally occupied an important position in the socio-cultural, spiritual, disease management, nutrition and beauty enhancement and in the livelihood security of the millions of people living in this region. However, over the first few decades, the availability of medicinal and aromatic plants is declining and some of them disappeared. Overexploitation is considered as one of the major causes of this problem. On the other hand, demands for medicinal and aromatic plants has risen in recent years very rapidly due to increasing requirements of medicinal and aromatic plants products as the public interest in the natural products is increasing. Accordingly, the market has been expanding rapidly and creating business opportunity for the people living in this region. On the other hand, it may have a great risk of either their extinction and or loss of genetic diversity, if such situation of increasing commercial interest continues, which will further create a risk of overexploitation. Thus, there is a need for a clear policy and strategy to conserve these variable resources without delay.

There is also need for increasing production and productivity of medicinal and aromatic plants to address poverty and food insecurity of the people associated with medicinal and aromatic plants in the wake of climate change impacts. We have to keep in mind that value of these plants is rich among the tribal and ethnic groups of these regions where the number of people living below poverty is still extremely high.

Ladies and Gentlemen, we have to move to restrict overexploitation of medicinal and aromatic plants from natural resource base and promote technology based sustainable cultivation practices as well as to adopt value chain approach for effective utilization. In view of that, this consultation is very timely.

We hope that in the course of two day deliberations and discussions, the consultation will be able to generate following six outputs: i) country status on medicinal and aromatic plants assessed and future needs of conservation and opportunities for development identified; ii) knowledge shared and experiences learnt on the use of improved technologies and tools for production and utilization of medicinal and aromatic plants; iii) awareness on the importance of medicinal and aromatic plants for enhancing cultivation and small holder farmers' livelihoods promoted; iv) policy option for conservation, sustainable production and utilization of medicinal and aromatic plants in different agro-ecological zones/countries identified; v) a regional strategy to promote medicinal and aromatic plants in Asia and the Pacific region developed; and vi) regional network on medicinal and aromatic plants established.

Medicinal and aromatic plants products are very suitable material to develop small and medium enterprise in our region if appropriately promoted with sustainable approaches. Technologies are available, and new and innovative ideas are emerging which can be transformed into small village level processing activities and medium enterprises. These crops can often be planted in waste and marginal lands with good returns and have the potential of employment generation as they involve range of activities like cultivation, processing, extraction, product formulation, fractionation, etc. These are all labour intensive activities and thus assist in reducing poverty both in rural and urban areas.

We are here today to reaffirm the importance of medicinal and aromatic plants in our life and society which is known to all of us. We are here today to discuss and exchange information among us in order to develop a regional strategy and networking so that we can transfer technology from one country to another country in order to enhance conservation, sustainable production and utilization of medicinal and aromatic plants at national, regional and international levels, and linking them with markets through value chain approach.

I sincerely hope that this consultation will achieve its intended results and would facilitate in framing a regional strategy and networking.

I wish a great success to this very crucial and timely event.

Thank you all again

Annexure II

Welcome Address

Raj Paroda
Executive Secretary, Asia-Pacific Association of Agricultural Research Institutions (APAARI)
Bangkok, Thailand

Dear Mr. Hiroyuki Konuma, Dr. S.P. Ghosh, Mr. Ranjit Puranik, Dr. Subash Dasgupta, various NARS leaders, distinguished participants, ladies and gentlemen.

At the outset, I would like to extend a warm welcome to you all to this important "Regional Expert Consultation on Promotion of Medicinal and Aromatic Plants in Asia and the Pacific region" being jointly organized by the Food and Agriculture Organization of the United Nations (FAO) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI). The goal of World Health Organization (WHO), about 'Health for All' cannot be achieved without the use of herbal medicines. The medicinal and aromatic plants do play a significant role in ensuring health security of almost 80 per cent of the world's rural population. Therefore, the need for plant diversity in medicinal and aromatic plants (MAP) is being realized mainly due to increase in population experiencing risk to health due to changing environment and life style, adverse side effects of chemical based modern medicines and other household products. Also, people are becoming increasingly aware of better healthcare.

The rich diversity of medicinal and aromatic plants, its indispensable use in social, cultural and health traditions and also as a source of raw materials for plant based products in modern industries has more importance and relevance today than ever before. Nowadays, the herbal products, which are less expensive and safe with high efficacy, are getting greater worldwide attention. Any threats to these vital and natural resources will not only jeopardize the livelihoods of millions of people but also the growing global market of medicinal and aromatic plants. Unfortunately, the MAP species are often called as non-timber forest produce (NTFP), and this sector has remained neglected in the past. Therefore, an urgent need was felt for a paradigm shift which requires due attention of policy planners and researchers with substantial enhanced funding support for conservation and use of MAP species.

The Asian region has an age old tradition of plant based healthcare system and detailed descriptions are available in the ancient literature. Out of 8,000 species of ethnobotanical importance available in Asia, 2,500 species are primarily used in different traditional medicine systems. The modern pharmacopoeia also has about 25 per cent component of plant based drugs. At present, 134 species of MAP are under cultivation, 160 species are partially cultivated and 250 species are traded in large volumes in the region. Among the top 15 countries which accounts for 72 per cent of the world trade in botanicals in Asia, China (11.48%) and India (8.75%) are at first and second position in world ranking in terms of value while in terms of volume, their ranking is second (9.92%) and third (8.75%), respectively.

The increased demand of raw material forced the overexploitation and unscientific collection of natural population of medicinal and aromatic plants from the forest rendering several species to vulnerable state of extinction. Therefore, an effective plant genetic resource management program needs to be developed by each National Agricultural Research System (NARS) to address the issues related to conservation and sustainable use of the genetic wealth of medicinal and aromatic plants. Due recognition needs to be given to the communities who have conserved these valuable resources and also showed us the way to use them in various ways though indigenous traditional knowledge (ITK). Therefore, conscious efforts are needed to document and revalidate the ITK properly before this wealth of knowledge disappears forever.

The cultivation of medicinal and aromatic plant species provides an added advantage by producing the uniform and consistent quality raw material. Therefore, the R&D efforts need to be reoriented so as to keep this sector free from the ill effects of chemical fertilizers and pesticides. The efforts are required to generate eco-friendly agro-technology to support commercial cultivation under organic environment with buyback arrangements with user industry. An effective and accredited mechanism needs to be in place for certification of organically produced MAP species in individual country with its recognition for international trade. The post-harvest management, monitoring the shelf life and need based value addition are equally important and requires full attention of individual countries. Concerted efforts are needed for quality testing, developing quality standards, and pesticide residue analysis of the produce using faster and accurate analytical procedures. The WHO has developed the guidelines for good agricultural and field collection practices (GACP). Accordingly, each country in the Asia-Pacific region should develop a set of guidelines for GACP and implement effectively at all levels to ensure the production of quality of raw material.

There are large number of medicinal and aromatic plant species. Therefore, it is necessary to prioritize the MAP species for research and development based on their medicinal use, market demand and other factors. Larger investments are needed to create R&D institutions and need based infrastructural facilities, since a few institutions with limited human resource cannot undertake the required R&D activities on all aspects of MAP species. Also, a national strategy for research and development on medicinal and aromatic plant species needs to be developed. The issues related to biosafety for human health would require adequate attention. Also, we need to bridge the knowledge gap and create appropriate R&D facilities. All stakeholders including farmers must come together to build required partnership with public and private organizations to share the knowledge and know-how.

Value addition is another important area in MAP sector which requires high priority. We also need enabling policies at individual country level as well as at the regional level. At present, no regulated market mechanism exists to control various marketing practices involved in the entire supply chain. Understanding of trade in medicinal and aromatic plants is far from satisfactory. The available data are not fully authenticated in the absence of required HS Codes which need to be addressed both at the country and the regional level. The farmers and collectors are not paid reasonable price of their produce and, therefore, at producers' level, Self-Help Groups (SHGs) and marketing cooperatives need to be created.

The participation of private sector at present is minimal and, hence, it is necessary to develop public-private partnership models where the private sector also contributes through funding,

helping in priority setting and also guiding the farmers for producing better quality material. There is a strong need to create awareness and undertake literacy campaign on intellectual property rights related to MAP species and training of human resource to make them familiar with latest technological advancements.

In view of these facts, the Regional Expert Consultation on Promotion of Medicinal and Aromatic Plants in Asia and the Pacific region has been organized at Bangkok, Thailand on 2-3 December, 2013 which is being attended by 38 experts and policy makers from 14 countries including the representatives from medicinal plants industry, FAO, and APAARI. The objectives of the consultation are to assess the current status of MAP species in Asia and the Pacific region and identify future needs, share knowledge and technologies, identify relevant policy options for strengthening conservation and sustainable development of these resources and strengthen regional collaboration through networking for promotion and sustainable use of medicinal and aromatic plants. Through this consultation, it is expected to consolidate the available information on production, R&D efforts and policy issues on MAP in the Asia-Pacific region. The consultation will provide a platform to the participants to share the knowledge and experiences and assess future requirements. Further, the consultation will facilitate to prepare the road map to accelerate the overall development of MAP sector taking into consideration the conservation of bioresources for sustainable use and produce the quality products for healthcare of people in the region. Therefore, an urgent need was felt to develop a Regional Network on MAP species in the Asia-Pacific region.

We fully appreciate the initiative taken by Mr. Hiroyuki Konuma, ADG FAO RAP in organizing this important regional expert consultation in collaboration with Asia-Pacific Association of Agricultural Research Institutions (APAARI). I also thank all the participants for accepting our invitation to participate.

It is our expectation that the deliberations during the next two days will culminate in useful outcome and recommendations. We need to develop a suitable regional strategy for the promotion of medicinal and aromatic plants in Asia and the Asia-Pacific region.

I wish the Expert Consultation a great success.

Thank you

Annexure III

Technical Program

2 December, 2013

Registration : 08:00 – 09:00

	Opening Session	
09.00 - 09.10	Welcome Address	Raj Paroda, APAARI
09.10 - 09.30	Inaugural Address	Hiroyuki Konuma, FAO RAP
09.30 - 09.55	Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region	S.P. Ghosh, Former DDG (Hort.), ICAR
09.55 - 10:20	Status of Utilization and Marketing of Medicinal Plants in Asia	Ranjit Puranik, MD, SDL
10.20 - 10.30	Vot of Thanks	Subash Dasgupta, FAO RAP
10:30 - 11:00	*Tea/Coffee Break and Group Photograph*	
Technical Session I: Country Status Reports – South Asia		
	Chair : Subash Dasgupta, FAO RAP, Thailand *Co-Chair* : N.M. Lita, Philippines *Rapporteur* : M.R.B. Awang, Malaysia	
11.00 - 11.20	Country report of Bangladesh	M. Shahjahan, BARC
11.20 - 11.40	Country report of Bhutan	D. Dhungyel, DOA
11.40 - 12.00	Country report of India	S. Maiti, ICAR
12.00 - 12.20	Country report of Nepal	T.P. Barakoti, NARC
12.20 - 12.40	Country report of Pakistan	M. Naeemullah, PARC
12.40 - 13.00	Country report of Sri Lanka	J.A.T.R. Jayakody, Kelaniya Univ.
13.00 - 13.30	Discussion	
13:30 - 14:30	*Lunch*	
Technical Session II: Country Status Reports – SE Asia and Pacific		
	Chair : T. Dhendup, DOA, Bhutan *Co-Chair* : T. Sugino, JIRCAS, Japan *Rapporteur* : L. Jung-Hoon, RDA, Korea	
14.30 - 14.50	Country report of Japan	K. Nakahara, JIRCAS
14.50 - 15.10	Country report of Malaysia	W.Z.W. Mamat, MARDI
15.10 - 15.30	Country report of Papua New Guinea	P.P. Rai, PNG Univ.
15.30 - 15.50	Country report of Philippines	C.C.de Guzman, Univ. of Philippines
15.50 - 16.20	*Tea/Coffee Break*	

16.20 - 16.40	Country report of Republic of Korea	P. Chung-Berm, NIHHS
16.40 - 17.00	Country report of Thailand	Charan Ditchaiwong, DOA
17.00 - 17.20	Country report of Vietnam	T.N. Hung, FVRI
17.20 - 17.40	Country report of Myanmar	Zin Zin Nwe, DFDA
17.40 - 18.20	Discussion	
19.00	*Reception Dinner hosted by FAO RAP and APAARI*	

3 December, 2013

Technical Session III: Policy Perspective : AR4D Strategies

Chair : S.P. Ghosh, Former DDG, ICAR
Co-Chair : Khalid Mahmud, MNFS&R
Rapporteur : S.R. Merry, DFRI

9.00 - 10.10	Perceptions of Panelists (10 minutes each)	R. Puranik, India T. Sugino, Japan H.K. Manandhar, Nepal M. Naeemullah, Pakistan N.M. Lita, Philippines Lin Chi Vu, Vietnam R. Ramani, India
10.10 - 10.40	Discussion	
10.40 - 11.00	*Tea/Coffee Break*	

11.00 - 13.00 Technical Session IV: Working Group Discussion

WG 1 : Production : Conservation, Improvement, Management
Convenor : S. Maiti

WG 2 : Utilization : Value Addition, Marketing, Export
Convenor : R. Ramani

WG 3 : Collaboration and Networking
Convenor : Subash Dasgupta

13.00 - 14.00 *Lunch*

14.00 - 15.00 Plenary Discusion on Recommendations of Working Groups

Facilitator : Raj Paroda, APAARI

15.00 - 15.30 *Tea/Coffee Break*

15.30 - 17.00	**Plenary Session**	
	Chair : Hiroyuki Konuma, FAO RAP *Co-Chair* : Raj Paroda, APAARI *Rapporteur* : Bhag Mal, APAARI	
15.30 - 16.30	Presentation of Recommendations	Rapporteurs/Convenors
16.30 - 16.40	Remarks by Co-Chair	Raj Paroda
16.40 - 16.50	Remarks by Chair	Hiroyaki Konuma
15.50 - 17.00	Vote of thanks	Subash Dasgupta

Annexure IV

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EXPERT CONSULTATION ON PROMOTION OF
ARTIFICIAL AND AROMATIC FLAVORS IN
THE ASIA-PACIFIC REGION

Tinospora cordifolia

Pantago ovata

Centella asiatica

Cassia angustifolia

Senna alata

Ocimum grastissimum

Mentha arvensis

Cymbopogon winterianus

Aloe barbadensis

Pogostemon cablin

Chlorophytum borivilianum

Panax ginseng

Asparagus racemosus

Withania somnifera