Biotechnology for enhancing Agricultural value chains

Thematic area: Medicinal herbs

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Abstract

Nepal is, paradoxically, a country rich in resources, and yet, lacks and lags in overall development. Out of 5856 flowering plants recorded in Nepal, 690 species are considered to have medicinal properties. Although medicinal herbs have been reported to have high export potential by *NTIS* 2010, the revenue generated from medicinal herbs represents less than 5% of the total revenue of the forest department. And the economy of the country shows a clear picture of poverty and stunted growth. So, this project aims at identifying the issues related to improper management of medicinal herbs in Nepal and proposing a solution through the application of biotechnology. This paper has shaded light on the discussion and analysis on how biotechnology/R&D can provide a new dimension to different innovations, produce a diverse array of novel value-added products and enhance the economic development of nation.

Interviews of 12 concerned stakeholders, 4 laboratory visits, 6 colleges 3 medicinal farm visits and in-depth literature review identify minimal focus on research and development in the medicinal herb sector, lack of commitment, insufficient budget allocation, unawareness and lack of medicinal herb based industries as the major challenges/constraints. These findings point out to the immediate need for a central biotechnology centre based on which advanced research and industrial production can be conducted simultaneously. Appropriate budget allocation and field level implementation of policies can be vital in the application of biotechnology for the economic development of the nation

Keywords: *NTIS*, Biotechnology, Medicinal herbs, R&D, Export potential

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Acronyms

BAB	Biotechnology and Biosafety
DPR	Department of plant resource
GC	Gas chromatography
GoP	Good laboratory practice
HDI	Human development index
HPPCL	Herb processing and production co. Ltd
HPLC	High performance liquid chromatography
HMGN	His Majesty Government of Nepal
ITC	International trade center
MAPDON	Medicinal and Aromatic Plant Database of Nepal
MAPs	Medicinal and Aromatic herbs
MoSTE	Ministry of Science Technology and Environment
NAST	Nepal Academy of Science and Technology
NARC	Nepal Agriculture Research Council
NBP	National Biotechnology Policy
NTFP	Non- timber Forest products
NTIS	Nepal trade integration strategy
NLSS-III	Third Nepal Living Standard Survey
R&D	Research and development
SoP	Statement of purpose
WHO	World Health Organization

Executive Summary

Biotechnology emphasizes on the innovative use of plants, animals and microorganisms for the generation of goods and services promoting human welfare. It is an area which holds a great promise for the economic development of a nation. Biotechnology has immense potential for the sustainable development of forests, agriculture and food grains, developing effective techniques for biodiversity preservation and industrial development. The fact that Nepal is blessed with the possession of diverse high value medicinal herbs and the evidence that the majority of its population relies on agriculture justify the urgent need for the utilization of biotechnology for the economic development of the nation through increased focus in R&D in the medicinal herb sector.

Methodology

During the period of three months, various quantitative researches on policies, strategies and existing reports on medicinal herbs and inclusion of biotechnology was carried out. Further analysis and data collection involved:

- Interviews and discussions with government level authorities, private/public research authorities , biotechnology associations, universities
- Laboratory/ research institute visits
- Field visit to herbal farm along with processing units
- Focus group discussions with experts and concerned stakeholders

Key Findings

- Inadequate prioritization of R&D in medicinal herb sector
- Limited awareness about their economical value
- Failure in the implementation of policies
- Disproportionate allocation of budget for research as well as commercialization in medicinal herb sector
- Use of primitive cultivation, harvesting and processing techniques
- Lack of central database and limited access to research information

Key Recommendations

- Development of infrastructure by applying competitive “lab to market” funding and incentives to promote committed participation by academia, the private sector as well as government-linked companies.
- Adoption of modern technologies like genetic transformation, bioreactor based technologies for production of transgenic plants and enhanced research into genetic diseases in plants.
- Fostering awareness on poverty issues and initiation towards commercialization and development of medicinal herb based industrial, thus maintaining the decreasing trend of poverty reduction.
- Adequate budget allocation from government side for technology transfer, laboratory accreditations, SoP implementation, and good laboratory practices.

1 Introduction

1.1 Background

Biotechnology has introduced a new dimension to different innovations, offering efficient and cost-effective means to produce a diverse array of novel, value-added products and tools. It is an area which holds a great promise for the economic development of a nation. Biotechnology has a great potential for the sustainable development of forests, agriculture and food grains, introducing new methods for the effective treatment of human health, animals and plants, developing effective techniques for biodiversity preservation and industrial development. But to promote biotechnological innovations for the economic development of the nation, research and development needs to be prioritized. Biotechnology policy 2006 provides high hopes among researchers that this government concern will provide a new direction to the economic development of the nation.

According to *NTIS 2010,* 19 goods and services have been chosen for trade having high export potential and MAPs and essential oils are one of them. Therefore, if the highest possible priority can be given to the frontier area of science and technology to conduct research in medicinal herbs by the government as well as private sectors and also to promote commercialization of these natural resources, the economic development will take a great turn.

The variations in climatic conditions and diverse topography of Nepal are responsible for the unique biodiversity consisting of around 7,000 species of plants. Out of these, 1,800 species are currently in use for the production of Ayurvedic, Unani, and Siddha medicines and for essential oils. About 250 species are endemic to the country, 1624 species are of ethno botanical importance and 100 of them are commercially important for trading and marketing. (Bhattacharya *et al*, 2003).

The use of medicinal and aromatic plants has directly contributed to the livelihoods of people in mountainous areas for centuries. More than 75% of people are dependent on the herbal plants as local source of medicine for their primary health care (Karki, 2000; Dutta and Devkota, 2001). 30% of pharmaceutical drugs were developed through an examination of the use of these plants in traditional medicines. There are many endemic species and some are on the verge of extinction too. On the other hand, some important species have been cultivated and are contributing to the national and local economy. The financial contribution made by NTFPs, especially medicinal plants, is much higher than the timber products (Karki 2000). But most of the raw materials are exported at low cost (Edward, 1996). Processing of these raw materials is very limited because of insufficient knowledge of modern technology (biotechnology) and the world market for the processed products.

This project aims at identifying the current status of biotechnology in Nepal, its potential for the conservation and utilization of medicinal plants and preparing action plans to develop incubation centres in Nepal, which in the long run will enhance exports of value added products from Nepal.

1.2 Biotechnology and Poverty alleviation

The NLSS-III (Third Nepal Living Standard Survey) carried out by the Central Bureau of Statistics (CBS) in 2010 and 2011 with technical support from the World Bank concluded that the poverty status of Nepal is about 25.16% and recorded a 5.7 percent decline in absolute poverty in between 2003-04 and 2009-10. The NLSS uses 2,200 calorie consumption by a person per day and access to essential non-food items as the index to measure poverty in Nepal. Based on current market prices, a person needs an income of at least Rs 14,430 a year to manage food equivalent to 2,200 calorie per day and other essential non-food items. An individual earning less than Rs 14,430 per year is below the poverty line. The results show that households led by agricultural wage workers are the poorest. However, Nepal has achieved remarkable progress over the past few years. The country managed to halve the percentage of people living on less than $1.25 a day in only seven years, from 53 percent in 2003-04 to 25 percent in 2010-11 and is continuing to make progress (World Bank). The recent data of economic survey 2014/2015 made by Ministry of Finance stated that the population living below the poverty line in Nepal accounts for 23.8 percent of the total population.

But despite some progress in recent decades, Nepal remains one of the poorest countries in the world with widespread poverty across the country. It ranks as the twelfth poorest country in the world. Nepal was one of the countries in Asia that recorded a significant improvement in the Human Development Index (HDI) over the decade but still the level of indicators is low, even by South Asian standards. Also, though the trend of decline in poverty rate had continued since last few years, the population size below poverty is expected to grow with likelihood of possible adverse impact of the recent catastropic earthquake on Nepalese economy. Despite few positive achievements, the structural reform and development efforts have not been made, poverty has still been pervasive, employment and income generating programs have not been effective in the rural areas, infrastructure development has not been widespread, economic growth has not been balanced across the regions, and the distribution of economic welfare has not been equitable. So, moving forward, Nepal needs to deliver more on its economic potential as the current growth rate is too low to reduce poverty. Nepal has a unique chance to end extreme poverty and spur more inclusive and sustained economic growth through new technology adoption (R&D) and industrialization.

An example of a country that necessitates research and development to eliminate poverty can be taken from Tanzania which is the 22nd poorest country in the world with over 30% of its population living below the international poverty line, earning less than 1 USD per day (Mtui, 2011). Realizing that, it considers biotechnology to be one of the means to rid itself out of poverty, ensure food security and public health. The Tanzania Biotechnology Policy (TBP) was approved in 2009. Its mission and vision is "to achieve significant investment in harnessing biotechnology tools for generation of products, processes and technologies in food, agriculture and health for socioeconomic development."

Similarly, Uganda is endowed with significant natural resources. Biotechnology in Uganda is set to contribute to the national goals of poverty eradication, improved healthcare, food security, industrialization and the protection of the environment. The Uganda National

Biotechnology and Biosafety (BAB) policy was approved by the Ugandan Cabinet in 2008. The policy, which was formulated by the Uganda National Council for Science and Technology (UNCST) in 2002, aims to build and strengthen national capacity in biotechnology through research and development, promote the utilization of biotechnology products and processes as tools for national development and provide a regulatory and institutional framework for safe and sustainable biotechnology development and application. The start of biotechnology in Uganda has been impressive, related activities of which are mainly being carried out by R and D institutions. There are still growing applications of biotechnology related to agriculture, natural resources, health, environment and industry such as tissue culture, production of transgenic crops, diagnostic tools, medicines, vaccines and hormones. The progress of biotechnology activities in Uganda is encouraging.

Nepal developed a biotechnology policy in 2006, after a thorough review and deliberation of various experts, scientists, stakeholders, academicians and planning commission officials. Its vision and mission is to reduce poverty from the country, rapidly addressing the existing problem of food, health, industrialization and environmental security for the sustainable development. A central problem for sustainable development is striking a balance between resource use and conservation so that high levels of development can be ensured. Therefore, conservation and wise use of natural resources has been an important global issue to be addressed from individuals and communities at national as well as international levels. In this concern, various biotechnological tools hold great promise in different areas of medicine, agriculture, forestry and environment to enhance food productivity as well as to promote industrialization, and maintain environmental integrity and biological diversity at ecosystem, species and intra-specific levels. A global trend of adapting biotechnology has proved to be a big challenge for the scientists and technologists around the globe to develop technologies, which in the long run, are able to overcome the existing poverty and are responsible for the sustainable development of the nation.

1.3Medicinal herbs overview

1.3.1 Medicinal herbs

The term NTFP was coined by de Beer and McDermott in 1989 and one of the categories of NTFP was MAPs. Among MAPs, some species are used for medicine, some for aromatic purposes, and many for both medicinal and aromatic purposes (Malla et al, 1996). Different parts of plants like seeds, berries, roots, leaves, bark, or flowers have been used for medicinal purposes. In the early 19th century, when chemical analysis first became available, scientists began to extract and modify the active ingredients from plants. Later, chemists began making their own version of plant compounds in search of novel drugs. Most of the pharmaceutical drugs we see nowadays are derived from botanicals. It is becoming more main stream as improvements in analysis and quality control along with advances in clinical research show the value of herbal medicine in treating and preventing diseases.

It has been estimated that about 10% of the plants or around 30,000 species are used for medicinal purpose throughout the world and out of which 6500 species found in Asia according to WHO report (2002). 70% of the world population use medicinal plants for curing diseases through traditional practitioners. The Himalayas are famous for medicinal

plants and have even been mentioned in the Ayurveda. Many of the herbs and plants found in the Himalayas are used in traditional healing systems like Ayurvedic, Homoeopathic, Amchi etc. Some of these plants are even used for allopathic medicine. Medicinal plants are abundantly found in: the Terai region of Nawalparasi, Chitwan, Bardia, Dhanusha, mid hill region of Makhwanpur, Syangja, Kaski, Lamgjung, Dolakha, Parvat, Ilam, Ramechhap, Nuwakot, and the Himalayan region of Dolpa, Mugu, Humla, Jumla, Manang, Mustang and Solukhumbu. The sectors of MAPs are a growing commercial sector in Nepal. Out of 5856 flowering plants recorded in Nepal (HMGN 2002), 690 species are considered to have medicinal properties (Malla and Shakya 1984). Out of this, 510 species are found in wild in Nepal, 120 species are in cultivation or have become naturalized, and 60 species are exotic. According to Medicinal and Aromatic Plant Database of Nepal (MAPDON), 1624 plants species have been listed as having medicinal use. Despite the efforts to conserve, 51 MAP species have been assigned to various threat categories as per the IUCN guidelines: 3 taxa as "critically endangered", 14 as "endangered", 23 as "vulnerable", 3 as "nearly endangered" and some of them as "data deficient" (Shrestha and Joshi 1996; Bhattarai et al. 2002). Because of the excellent network of protected areas in Nepal covering about 20% of the country's land, MAPs are well protected.

In Nepal 75% of the population, especially in rural areas is getting health care by traditional practitioners who prescribe herbal preparations (Hasan, Gatto and Jha, 2013.) In general, herbs collectors are using traditional knowledge for pre- and post-harvesting operations and processing. The uncontrolled commercial extraction has significantly eroded the country's medicinal plant resources, and particular species have gradually become more difficult to find in a given locality where they once flourished. Thus the availability of the high-altitude herbs supplying underground part: *Aconitum ferox*, *A. heterophyllum*, *A. spicatum*, *Dactylorhiza hatagirea*, *Nardostachys grandiflora*, *Panax pseudoginseng*, *Picrorhiza scrophulariiflora* etc which were once abundant, has declined drastically in recent years. The supplies of middle- and low-altitude herbs like *Asparagus racemosus*, *Dioscorea deltoidea*, *Rubia manjith*, *Valeriana Jatamansi*, tropical and sub-tropical herbs like *Alstonia scholaris* and *Rauvolfia serpentina* have already reached near extinction levels in most areas of the country.

There is scope for reducing wastage, conserving the valuable species of Nepal and improving quality through research and development, and proper training and the introduction of information management systems.

1.3.2 Value of medicinal herbs

Relevant information on the volume or value of the trade in medicinal plants is not accessible as trade statistics do not identify all the plants individually. The situation regarding trading of medicinal plants is rather more complicated because of the levels of secrecy maintained by traders and the complexity and the disorganized nature of the trade structure/channel itself. International trade centre's (ITC) reports on medicinal plants and extracts also address the lack of readily available market information on the international trade of medicinal plants produced and exported by developing countries and least developed countries.

Medicinal plants are primarily used for therapeutic, aromatic and/or culinary purposes as components of cosmetics, medicinal products, health foods and other natural health products. They are also the starting materials for value-added processed natural ingredients such as essential oils, dry and liquid extracts and oleoresins. These utilities necessitate the clear industrial demand for MAPs. Finished products made from medicinal and aromatic plants are increasingly prescribed and bought over the counter. The global market for botanical and plant-derived drugs was therefore expected to increase from $19.5 billion in 2008 to $32.9 billion in 2013 at an annual growth rate of 11.0%, according to a 2009 study by BCC Research.

Global market for herbal products is estimated to be over USD 60 billion as stated by World Health Organization (WHO) and over 80% of the world population relies on traditional plants based medicines. Europe is estimated to be accounting for 51% of the world market, other markets being China, USA, UK where trade in herbal medicines is estimated to be growing at an excess of 10% annually.

1.3.3 Research and development for value added products in Nepal

Role of science and technology (S&T) in a nation's development is obvious. Recent advances in biological applied sciences and basic science is due to enthusiastic research in the country. However, developing countries are less benefited from these researches than developed countries. This is due to small budget allocation for science and technology which is a major constraint in the development. Some of the developed countries have their international agencies for bi-lateral and multilateral co-operation and funding in developing countries but the development of S&T in a country like Nepal depends on such funding. The amount of funding may be small but can give an excellent outcome if properly utilized. (Shrestha B, 2003)

Nepal is investing negligible funds in the development of science and technology. Out of total 16.5% budget for education only 1.2% is fractioned for science and technology. It includes general, applied and technical science education investments. Expenditure in scientific research and development activities covers roughly 0.3% of GNP.

Table 1: National Expenditure in Research and Development in Nepal

Year	**Research and Development Expenditure as % of GDP (In Average)**
2008	0.05
2009	0.26
2010	0.3

Source: UNECSO institute for statistics

Considerable research and development works have been carried out in agriculture, food, forests and plant resources sectors but still the sector of medicinal and aromatic plants has been a vastly unexplored, under- utilized component of forestry in Nepal. People in the hills

and Himalayas practice collection of herbs to augment their source of income. Above 90% of these herbs are mostly exported out of the country in crude form or in semi-processed form. Also, market demand causes pressure on wild collections causing different plants to become rarer (Sharma U, 2007). Some of these valuable and economically important plants are in the verge of extinction. Therefore, although MAPs can contribute immensely to revenue collection as well as improving the socio-economic status of the Nepali people mainly living in rural areas, a number of problems at the level of production, processing, and value addition need to be properly addressed.

Table 2: R &D Expenditure on Agriculture, Forest and Soil Conservation of Total Budget

Sector	**R&D expenditure as % of Total budget**
Agriculture research and development	13.3
Forest and Plant Resources	6.1

Effective research and development for the production of value added products will make the country's economy strong and will also support the livelihood of local villagers. This will reflect the national progress and prosperity in all-round development. On the top of this, the advanced technology shows the position of a country in world's technological arena.

1.4 Objectives

The objectives of this project are to:

- Study the government proactive policies and directives concerning Biotechnology in Nepal.
- Assess the current biotechnology status in Nepal and identify issues, problems and challenges for the growth of this frontier area.
- Identify the priority areas where biotechnology could help to uplift the nation's economy.
- Identify how biotechnology could enhance the agricultural value chains.
- Review existing policies and strategies for management and commercial promotion of Medicinal herbs
- Explore existing flaws in the processing of value added products extracted from medicinal herbs
- Recommend appropriate measures for sustainable cultivation of medicinal herbs and feasible technology adoption.

2 Methodology

2.1 Research

2.1.1 Desk research

The study is largely based on the desk-study with extensive use of secondary sources. Study of prevailing laws, regulations, plans and policies related to biotechnology and its contribution to MAPs and production of processed products was conducted to analyze the government's efforts for the development of these sectors. Also, existing reports and past reports were reviewed to understand ongoing research and development in medicinal herbs. International trade of MAPs and essential oils and Nepal's participation in such trade was analyzed based on research and data collected from different sources.

2.1.2 Field research

Identification of different research organizations so as to understand the constraints faced by them in research and development was conducted. Some additional consultations with professional experts, research institutions, government and non-governmental organizations were also carried out.

Research Questions

Ques1: What is the present status of biotechnology, R&D in Nepal?
Ques2: What major problems do we face during research in medicinal herbs sector?
Ques3: Is the contribution of medicinal herbs in present scenario sufficient enough for the nation's economic development and poverty eradication?
Ques4: What initiatives have been taken by the government in conservation and appropriate utilization of medicinal herbs?
Ques5: In what scale will commercialization of value added products contribute to the nation's economy?
Ques6: How has Biotechnology policy 2006 helped reduce the poverty till now?
Ques7: How many research institutes in Nepal have given tangible benefits to the nation's economy, agriculture, health and environment sector?
Ques8: What is the difference between the private and public level research institutes in terms of equipments and level of research? Should there be collaboration between private and public level research institutes?
Ques9: What is the government's perspective towards research and development?
Ques10: Is present year's allocated budget for research and development sufficient enough to conduct research in various sectors? If yes, is budget the main issue?
Ques11: Do you think brain drain has influenced nation's development? If yes, how can we minimize brain drain?
Ques12: Is there a lack of collaboration and co-operation between government and private sector? If yes, how it can be improved?
Ques13: Since applications of biotechnology cover various sectors, what can be the possible way to unite different sectors like plant, animal, medical, genetics etc?
Ques14: How can the government help to flourish biotechnology to enhance agriculture value chain?

Ques15: What can be the possible provisions to make people aware about patent portfolio or innovations?

2.2 Research Design

For the preparation of this report following approaches and methodologies were carried out:

- **Biotechnology Sector Identification**: Major areas of Biotechnology (Medical, Agro-forestry, Agriculture, Environmental, Forensic, Bio-energy, and Biotechnology Education) sectors were identified for the technical survey.
- **Stakeholder Identification**: Possible Stakeholders and officials from government, Semi-government sectors, and scientists from public and private research institutions were identified and listed. .
- **Questionnaire/ Checklist Preparation**: The questionnaires were developed which were also interacted and discussed among the scientists from different areas of biotechnology, members of National Biotechnology Advisory Committee as well as with the experts from various sectors.
- **Interview and Survey**: Key informants listed for various sectors were interviewed using the questionnaire. Interviews of stakeholders were carried out to identify the current policies related directly or indirectly with modern biotechnology and their implementations. For many of the institutions, personal laboratory visits were also carried out. For identifying the technical problems in medicinal herb farms, and studying how biotechnology can contribute in the development of the sectors, field visits were carried out and concerned people were interviewed.
- **Data Compilation**: Acquired data were checked, compiled in tabular form following simple qualitative analysis in various areas. Survey findings were discussed with the experts in order to identify the solution

2.2.1 Organizations surveyed

Table 3: Organizations involved in R&D

Name of the organization	Type of organization	Service	Interviewed person
National Academy of Science and Technology (NAST), Khumaltar	Semi- government	Research	Dr. Sangeeta Shrestha, Senior Scientific Officer and Unit Chief, Molecular Biotechnology Unit.
Biotechnology unit, Nepal Agricultural Research Council (NARC), Khumaltar	Semi government	Research and education	Dr Bindeshwar Prasad Sah, Senior Scientist, Chief Biotechnology unit
Department of Plant Resources (DPR), Thapathali	Government	Research, analysis	Dr. Sabrina Rajbahak , Assistant Scientist

National Herbarium and Plant Research Laboratory (NHPL), Godawari	Government	Research, development and education	
Centre for Molecular Dynamics (CMDN), Thapathali	Private	Research and education	Dr Sameer mani Dixit, Country Director, CMDN
Research Institute for Biosciences and Biotechnology (RIBB)	Private	Research and education	Dr. Janardhan Lamichanne, President
Herbs Production and Processing Co. Ltd (HPPCL)	Government	Research, analysis and commercialization	Mr. Sudarshan subedi, Chief planning officer
Research Centre for Applied Science and Technology (RECAST)	Semi –government	Research. Development and education.	
Kathmandu Centre for Genomics and Research Laboratory	Private		

Table 4: Universities in biotechnology sectors

University/ colleges	Type of university	Service	Interviewed person
Department of Biotechnology, Kathmandu University, Dhulikhel	Public	Research and education	Dr. Janardhan Lamichanne, Professor, Biotechnology
Department of Biotechnology, Tribhuvan University, Kirtipur	Government	Research and education	Dr. Bijaya Pant, Professor, Biotechnology and Biochemistry Dr. Pramod Kumar Jha, Head, Central Department of Botany
Purbanchal University affiliated colleges (Asian Institute of Science and Technology, SANN International College, Kantipur Valley College)	Public	Education	Dr. Mukund Ranjit, Principal , SANN International College

Table 5: Farms and biotech nurseries and associated traders of medicinal herbs

Farms	Type of farm	Service	Person interviewed
Belbari medicinal farm	Government	Cultivation and extraction	Mr. Takhad Bahadur Sawat
Tarhara medicinal farm	Government	Cultivation and extraction	Mr.
Nepal Biotech Nursery	Private	Cultivation and research	Mr Nabin Sahukhal, Nursery head
Jadibuti Association of Nepal (JABAN)	Semi-government	Trading	
Himalayan Biotrade	Private	Trading	Ms. Saraswati Rai

3. Nepal's perspective towards value added products

Biotechnology being a multidisciplinary subject, directly or indirectly encompasses a wide range of areas including microbiology, genetics, biochemistry, bioinformatics, agriculture, botany. In this present report, biotechnology encircles all these disciplines as it clear that the overall process for the industrial production of goods and services involves the input of all these sectors directly or indirectly.

3.1 Policy Implementation

The government of Nepal has identified the biotechnology sector as one of the key strategic sectors that will support the growth of the Nepal economy. It is anticipated that growth in the sector will be supported by leveraging on the strength of the country's diverse natural resources and cost effective human capital talent pool. Our country which is deemed to be rich in biological resources requires the step forward in science and technology with the realization of traditional knowledge and modern technology. So, the government has identified the need to create a strong supporting framework to facilitate the long term growth of the sector. In 2006, the Nepal government enacted the National Biotechnology Policy (NBP 2006) to achieve this goal. The policy highlights the benefits of this sector and application as the basis of key substitute for the development of the country. One of the applications is in the growth of the industrial biotechnology sector.

Innovation is not the outcome of a single policy but rather of a set of policies that work together to shape innovative behaviour. To support research and development, various other national policies, plans and legal documents exist in various disciplines with an objective that are directly or indirectly related to biotechnology and agro-biodiversity and development of NTFP(medicinal herbs)

Table 6: List of Policies associated with Medicinal herbs

List of policies	**Published Year**
Three year plan	2012
The Three-year Plan Approach Paper	2010-2013
Three-year Interim Plan	2007–2010
NTFP Development Policy (HNDP)	2004
Nepal Agro-biodiversity Policy	2007
Forest Act	2023B.S.
Medicine/ Drug Act	2035 B.S.
Trade policy	2009

Some important issues that have been incorporated in these plans and policies are inclusion of technology for the development of local and national level economy. Despite immense efforts on policy making there remains a gap in constant technology advancement and adoption of appropriate technology to uplift industrial sector and produce quality products to enhance competitiveness. Poverty alleviation by generating employment opportunities has also not been achieved as expected. Crisis of manpower and budget in research and development has been detrimental to the expected growth. Biotechnology related information retrieval system for scientific community in Nepal is still in infancy. Various public and academic institutions do not have libraries, internet and PERI journal access, which is an obstacle for full-fledged research in various fields.

3.2 Research scenario in Institutes

During this study, different government and private institutes were surveyed and concerned stakeholders were interviewed. Out of 23 total interviewed and surveyed institutes, 6 were government and semi-government institutes, 5 were research institutes, 5 were public universities/colleges, 1 was a government university, 2 were herbal nurseries, 2 were herbal farms and processing units and 2 were traders of MAPs semi processed products.

Table7: Number of organizations involved in R&D

Type of organizations	**Number of organization surveyed**	**Number of organization involved in R&D**
Government research institutes/ Departments	6	5
Research institutes	5	4
Universities/Colleges	6	3
Business/ Enterprises	2	0
Herbal farms/Processing units	2	0

Although data shows that a lot of institutions are involved in research and development activities, these research levels are only limited to conventional practices. There is no technological advancement and none of the institutes are involved in manufacturing and producing biotechnology products in pivot scale. The majority of research is limited to paper work. Regarding the publication of S&T related statistics and journals, 55% of them are publishing it either in the form of journals, annual reports, progress reports, proceedings etc. and 45% do not publish any type.

Out of the total research institutes/laboratories surveyed, 4 were involved in research of medicinal herbs:

- Department of Plant Resources
- Research Centre for Applied Science and Technology (RECAST)
- National Academy of Science and Technology (NAST)
- Research Institute for Biosciences and Biotechnology (RIBB)

Based on interviews and surveyed data, it can be analyzed that the research is more restricted to tissue culture and extraction of essential oils rather than further production of value added products

- **DPR**: Research in the Department of Biotechnology is only limited to plant tissue culture. The plantlets generated from tissue culture are cultivated in 7 botanical gardens located in Illam, Kailali, Makwanpur, Dhanusha, Salyan, Banke, Jumla. The processing of these medicinal herbs is limited to extraction and estimation of essential oils & physico-chemical analyses (Color, odor, taste, solubility, specific gravity, refractive index, optical rotation, acid value, ester value, ester value after acetylation & formylation, carbonyl content, phenol content and also thin layer chromatography, GLC, GC_MS & HPTLC) and trading.

- **NAST:** Modernization of indigenous technologies along with identification & facilitation of the appropriate technology transfer is practised. The primary focus is on molecular characterization, bio-prospecting of high altitude plants. Barcoding is currently a widely used and effective tool that enables rapid and accurate identification of plant species. Similarly, NAST is also carrying out molecular based diagnosis of diseases in plants using PCR techniques. Although, various research has been conducted in medicinal plants but the findings are mostly limited to paper publications. One of the major contributions in research and development is the establishment of High Altitude Pyramid Laboratory at Lobuche at 5500 m altitude in collaboration with Italy. Different research activities are carried out at this laboratory involving climate change, Himalayan environment and geology, high altitude flora and fauna including human physiology. Now, Faculty of Science is focusing on the study of Manaslu conservation area for the study of ecological and biodiversity aspects.

- **NARC:** Biotechnology unit of NARC is working specifically on tissue culture based research on *in-vitro* mutagenesis and micro-propagations, genotyping, molecular breeding and molecular markers. This research targets only the substantial crops but does not involve medicinal herbs.

- **RIBB:** It is involved in the survey and screening of Nepalese medicinal plants for antibacterial, antifungal and antiviral activities. Also, it carries out Isolation and characterization of bioactive compounds isolated form medicinal herbs. Results are mainly confined towards the paperwork rather than manufacturing and commercialization.

Similarly, several private research laboratories are also working on medicinal herbs sector but the research is only limited to identification and essential oil extraction and commercialization of some processed products like soaps, ointments.

3.3 Processing practice

Different varieties of essential oils are processed in Nepal considering both the domestic and international markets. But, very often, both the quantity and quality are inappropriate for sale to international communities. The supply of MAPs and essential oils from Nepal is not enough and sustainable. For example, demand of lemongrass is high in the international market. But Nepal's production of lemongrass is not even 10 tons a year, whereas India's production of lemongrass per year is about 15,000 tons. Therefore alternate methods, research and adoption of modern technology (biotechnology) or plant tissue culture is required in order to generate more plantlets within a shorter period of time.

Moreover, there is also a need for technology adoption for seed preservation. In fact, some of the varieties such as chamomile were introduced to Nepal by bringing seeds from other countries initially. Even today, the sources of seeds for such MAPs are foreign countries. Adequate efforts have not been made till now on research and development towards generation and preservation of new seeds and value added products.

3.3.1 Processing and cultivation units of medicinal herbs

16 different companies/ entrepreneurs in Nepal are involved in commercial processing or value addition of medicinal herbs , some on small scale for local markets while other on larger scales for national or international markets.

A large number of industries are spread over different parts of the country. Most of the organizations operating from within the valley have their farms outside the valley where cultivation is carried out. However, their exact number and quantity of consumption is unclear. Furthermore, large numbers of species are processed locally using conventional methods. The processed products do not involve the use of modern technology applications.

It is easier to export MAPs to India, the major export destination for Nepal, in raw forms than in processed forms due to stringent rules and also higher duties and charges for exports of processed products in India. Also, in case of medicinal plants, there is not any specific general processing technology. Another challenge regarding processing is that Nepal's supply capacity is extremely limited compared to that of India. Therefore, Nepal does not enjoy economies of scale due to which it has not been able to import modern technologies to ensure the quality of its products. Relying on old and traditional technologies causes deterioration in quality of products. Hence, stakeholders prefer to export MAPs to India in raw form, where processing and further value addition is done in a large scale through the use of modern technologies and skilled human resources.

There are 77 processing facilities set up in the country by the private sector including those in Banke and Bardiya districts. But these facilities have either not been brought into proper use and/or the quality of products obtained through processing in some of these facilities have been inferior. Also there is lack of skilled human resources to run modern processing plants.

Table8: List of some of the Kathmandu based processing and production unit

S.N.	Name of processing centers
1.	Herbal Processing and Production Co. Ltd
2.	Singh Durbar Baidhyakhana Bikas Samiti
3.	Dabur Nepal Pvt. Ltd.
4.	Gorkha Ayurved Company
5.	Natural Resources Industry
6.	Alternative Herbal Products Pvt. Ltd.

Field survey

Belbari

Belbari lies in Morang district and has a population of about 15,154 including 2,826 households' people, spread across 4 VDCs and 17 villages. The average household size is about 8 persons per household. Belbari municipality is mainly characterized by strong terrain and fertile land where the larger flatland is compulsorily used for farming. Due to the dense forest resources, a number of small streams and wetland, for instance Amuna khola, Sisauli khola and Betana wetland, are available in this area and those water resources assist in farming. Paddy, maize, wheat, mustard, varieties of vegetables such as cauliflower, potatoes, ginger, onion are the principal crops grown in this area. Apart from this, people are also engaged in the medicinal herb farm. This farm has an area of 40 hectare and the cultivated species includes Citronella, Lemon grass, French basil, Mintha, Camomille, Eucalyptus, Palmarosa. The farm also has processing and production units. The steam distillation method is used for essential oil extraction. According to the survey, they have been practising this technology since it

4.Socio-economic impact of medicinal herbs

NTIS 2010 has been developed to chart a possible course for the development of Nepal's export sector over the next three to five years, together with possible capacity development actions and selected short- to medium-term priorities that are supportive of inclusive growth. *NTIS 2010* has ranked MAPs and essential oils as high in terms of its socio-economic impact, and medium in terms of export potential.

Herbal remedies are increasingly becoming mainstream consumer products manufactured by multinational companies. The diverse geography and climate of Nepal has rendered it a unique land of NTFPs along with other natural resources. However, the commercial exploitation without any conservation measures has threatened many species. The high mountains are highly praised for high value (potency) NTFPs, hence they fetch higher prices. In spite of all advantages, the country is not able to harness the full potential of NTFPs for the welfare of Nepalese and their economic development. In 2007/08, a total of NPR 29 million was recorded as royalties. Attaria and Tanakpur in the Far-Western Region (30%), Nepalgunj in the Mid-Western Region (50%), Butwal in the Western Region (4%), Trishuli and Kathmandu in the Central Region (9%), and Basantpur in the Eastern Region (7%) are the collection and marketing centers for herbs in Nepal. There has been a drastic reduction in herbs collection for the previous five years (2002/03 to 2006/07) and the reasons for this are not clear.

However, the situation has recently been changing with exports of 5,540 MT of 40 species of crude herbs valued at NPR 400 million. Data from Nepalgunj customs in 2008/09 indicates that total exports could have surged to about 10,000 MT. Ten to fifteen thousand tons of crude medicinal herbs of more than 100 species are collected annually from forests and pastures, many of which are exported to India. This trade is an important source of livelihood and cash income (estimated to be in the order of 10 million US Dollars in Nepal) for rural communities.

More than 90% of the collected crude herbs are exported to India without processing and some of the restricted species are smuggled. Informal and unrecorded exports to India from porous borders are also thought to be of a substantial amount. Although western region of Nepal are involved in medicinal herbs collection and cultivation activities but the poverty level of these areas are high as recorded by census.

Table9: Poverty rate of Western Region, Nepal

Regions	Poverty rate	Poverty gap index
Mid western	31.86	7.74
Far western	45.61	10.74

Promoting local processing would allow the Nepalese MAPs sector to keep a bigger part of the value chain at the local level and uplift the local level economy. The major constraints for such situation are considered to be low capital investments both by the government and private sectors for the overall promotion of NTFPs including enterprise development and the perpetual marketing of quality products, government's unclear investment policy, lack of proper documentation on species availability (including bio-prospecting) & uses and poor awareness among public on its values.

Trade in herbs is not a new practice for Nepal. It was described in Sanskrit legends 3,000 years ago, was encouraged by unified Nepal's first ruler in the 18thcentury, and has been described by European travellers from that time onwards (Edwards, 1996). The international demands for natural products, and hence medicinal plants, are increasing at an alarming rate due to the tendency or fashion of modern people for their use in personal health care, cosmetics, etc.

Table10: E**stimated demand (Kg) of key medicinal plants in 2069/70 in Indian sub-continent**

S.N.	Local name	Scientific name	Demand (kg)
1.	Padamchal	*Rheum australe*	128272
2.	Chiraita	*Swertia chirayita*	36088
3.	Bojho	*Acorus calamus*	140386
4.	Tej patta	*Cinnamomum tamala*	715365.5
5.	Kakarsinghi	*Pistacia chinensis*	2887
6.	Kutki	*Picrorhiza kurrooa*	94685
7.	Sarpagandha	*Rauvolfia serpentina*	588
8.	Sugandhawal	*Valeriana jatamansi*	45205
9.	Timur	*Zanthoxylum armatum*	390802
10.	Kaulo Bokra	*Machilus macrantha*	1327687.5

(Supply from Nepalgunj and Banke)

Some of the species under trade with India also have handsome industrial demand in the Kathmandu valley. However, the demand in Kathmandu valley is not competing with Indian trade. Demand from Indian Trade Centre seems focusing more towards medicinal plants whereas the demand in Kathmandu valley is diverse and focusing more towards aromatic plants/products.

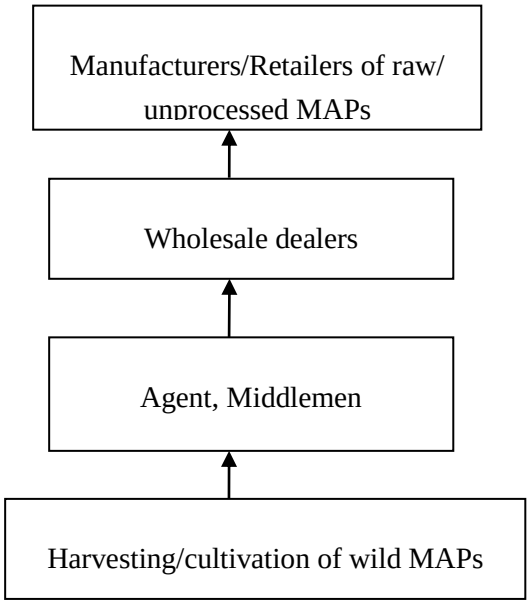
The study states that NTFPs, more specifically MAPs, can contribute immensely to revenue collection as well as improving the socio-economic status of the Nepali people mainly living in rural areas. However, a number of problems at the level adoption of modern technology in production, harvesting, marketing, processing, and value addition need to be properly addressed to realize the benefits.

4.1 Value chain of MAPs:

Input supply, production and local processing at farmers level (for cultivated items); collection, domestic trading and exporting at traders level (for wild harvest); and processing and manufacturing for value addition at processors/ manufactures' level are the functions involved in value chains of medicinal plants. The function of final processing and manufacturing is in limited form within Nepal. Some manufacturing companies involved in Ayurvedic productions, herbs based personal care

producers, and health care herbal products producers, etc. have been using MAPs and processed products as an ingredient in their various products.

General trend of trading products from Nepal



About 90–95 % of MAPs in Nepal is collected from the wild. Cultivation of MAPs is carried out in a very small scale. There are a number of problems and challenges in the cultivation of MAPs because of which collection from the wild is preferred over cultivation and due to lack of awareness and training; the harvesting is not practiced in a sustainable manner. Poverty has also been a huge contributing factor to unsustainable collection of MAPs since local level collector's priority would be to fulfill their immediate needs rather than think of the future. There are also no common guidelines prepared for the collection of MAPs. It is true that cultivation ensures more sustainable supply of MP than collection from the wild. But in the case of Nepal, there are a number of problems. For example, there is lack of market information, unavailability of quality seeds, etc. due to which cultivation of MAPs is not carried out on a large scale. MAPs also have longer gestation periods and so farmers have to wait for longer years to realize income from its cultivation.

4.2 Existing standards and quality maintenance

In today's globalized world where there is a stiff competition between countries to sell similar products, and where the people are more concerned about the standard and quality of products, good quality and value added products is a necessity. From an international trade perspective, product standards are mainly discussed under two categories:

(i) Related to food safety and human, animal or plant life or health, covered by the SPS Agreement of the WTO,

(ii) Related to processing and production methods, testing and certification procedures, packaging, marking and labeling, covered by the Agreement on Technical Barriers to Trade (TBT) of the WTO.

In the case of MAPs and essential oils, which are used in manufacturing/preparing medicines, food supplements and other products for human consumption, ensuring and maintaining quality and standard of products is very important. Laboratories in Nepal are basically limited to the checking chemical composition to ascertain whether the product is adulterated or not, and certifying that containers have been sealed for export by air. Department of Plant Resources (DPR), Ministry of Forest and Soil Conservation, Government of Nepal, is the central agency authorized to issue quality certification, but the laboratory equipments that DPR has been using have been in use for a long time. Therefore, they might not produce correct results at times. As a result, many importing countries do not accept the quality certificates issued by DPR. Some of the importing countries also demand pest testing data of medicinal plant but Nepal does not have even basic pest data of listed medicinal plants because of which exports are hindered.

Another aspect regarding quality is that many traders export their products to buyers in India who do not care much about quality, and are involved in the use of MAPs and essential oils imported from Nepal to produce inferior quality products. This has led to complacency of Nepali exporters in receiving whatever price their exports fetch, despite the potential to receive premium prices by ensuring good quality of their products and targeting high-end buyers. The process of extracting MAPs determines how efficiently we add value to MAP bio-resources. In the case of essential oils, the extraction process affects the physical as well as internal composition. External appearance, at times, can result in rejection of the batch even if the analytical results are within acceptable limits. Furthermore, essential oils are evaluated internationally for their olfactory properties by experienced perfumers and these olfactory qualities supersede analytical results. Variations in the chemical constituents of the extracts of medicinal plants may result by using non-standardized procedures of extraction. Efforts should be made to produce batches with quality as consistent as possible Also to address all such problems, development of national level incubation center as well as industrialization is the best solution where all research and quality assurance tests can be conducted.

There has not been enough research in the area of MAPs and essential oils from both government and private sectors. There could be a number of plants possessing medicinal or other important properties in Nepal, but this aspect has been under researched. Research has also been insufficient in the areas of processing and manufacturing techniques.

4.3 Intellectual property right

The use of intellectual property rights (IPRs) in the case of MAPs and essential oils has to be seen from two perspectives. The first is regarding traditional knowledge possessed by communities about the inherent qualities of MAPs and the medicinal and other uses that these can be brought into. Such traditional knowledge should be protected by means of IPR. However, since such knowledge is possessed not just by an individual but the whole community, it cannot be protected by any private form of IPR. Any benefit arising out of the use of such knowledge should be shared among the community possessing the knowledge. This aspect of protection of IPR and sharing of benefits is covered by the draft Access to Genetic Resources and Benefit Sharing Law, which was prepared in 2002, but is yet to be enacted. However, IPR and benefit sharing from this perspective does not apply to current exports of MAPs and essential oils from Nepal since they are exported as raw materials to be put into various other uses, based on commonly held knowledge.

The second issue is regarding the use of trademark or collective mark. It is said that essential oils produced in Nepal are organic by default and are of high quality. However, there are problems in getting them tested and certified. If quality is maintained and proper testing and certification can be

ensured, collective mark can be used to distinguish essential oils produced in Nepal from those produced in other countries.

Regarding the patent issues, on interviewing Ms Shailaza Shrestha, Patent unit, Department of Industries, it has been found that there is no such patent recorded in Nepal in case of medicinal herbs, but one is under process namely “Kalpasadan” by Mr. Kamal Raj Joshi, which has been claimed to cure cancer treatment.

5 Recommendations

5.1 Biotechnology development

- **Commitment**: Nepal has been lagging behind in biotechnology, existing human resources, and infrastructure and also in budget allocation by the government in research and development in biotechnology. Due to this, Nepal is not able to keep pace with the rapidly evolving modern technologies and has been unable to adopt them for the development of nation. In order to make a strong hold on these newer technologies, a strong national commitment from the government side is needed for the overall development of biotechnology in various sectors and for the economic enhancement of the nation as a whole.
- **National biotechnology research centre**: Existing policies about the establishment of a national biotechnology research and development center should be implemented, where multidisciplinary research teams can come together and work in coordinated research and commercialization initiatives. Development of well a equipped national laboratory with reference data, standard quality methodology and organic certifications is necessary.
- **Prioritization of research and development**: Prioritization of R & D areas in biotechnology favoring high tech instrument, methodologies, modern technologies at national level, easy accessibility of websites or databank sharing research outcomes/ information among public-private sector institutions, is recommended. There should be provision of attractive scientific incentives for R & D through the establishment of competitive grant system at national and international levels. Adaptation of well proven mature technologies in various disciplines such as medicine, agriculture and environment is the need of current scenario of the country.
- **Industrialization:** Development of infrastructure by applying competitive "lab to market" funding and incentives to promote committed participation by academia, the private sector as well as government-linked companies is recommended. There is a need to transform and enhance the value creation of the agriculture sector through biotechnology by capitalizing on the strengths of biodiversity in order to commercialize discoveries in natural products so as to promote the position of Nepal in the bio-generics market. It is also recommended to build the nation's biotech human resource capability in line with market needs through special schemes, programs and training.
- **Budget**: Allocation of adequate budget from the government is recommended which would directly promote technology transfer, laboratory accreditations, SoP implementation, good laboratory practice (GOP) and equipment calibration. Development of sector wise database of human resources and budget investment including budget for R&D in different thematic areas would be helpful for future reference.
- **Provisions from the government side**: Private, public or government level institutes/organization/industries/universities should set aside 5% of the total budget for

research and development. Incentives should be given for those organizations by deducting 10% of the tax for those who have a laboratory and conduct research and development. Also some part of this research funding should be given to university students during their thesis to conduct global standard research using sophisticated technologies.

- **IPR Issues**: Amendment in the policies to create an enabling environment through continuous reviews of the country's regulatory framework and procedures in line with global standards and best practices is recommended. There is also a need for development of protocol and a strong intellectual property protection regime to support R&D and commercialization efforts. As the access and benefit sharing issues of biodiversity and conservation and sustainable utilization of natural product issues are not clear in national policies, they should be revised and reformulated. Furthermore, indigenous traditional knowledge protection and information sharing issues are also not clear.
- **Incentives from government**: Tax write-offs for companies whose subsidiaries invested in biotech sector and suffered losses, should be implemented. For an example, if the subsidiary lost $2 million, the loss can be subtracted from the tax-deductible profits of the parent company. The government is trying to mitigate risks so that the companies will be motivated to move into the industry. The government has also agreed to allow retired scientists and lecturers to continue to do research until 65 years old (existing retirement age is 56). $26 million is being allocated to biotechnology infrastructure that will be used to bear the cost of maintaining the services of these scientists to help develop the biotechnology sector.

5.2 Value added medicinal herbs processed products

The trend in trade of MAPs and essential oils is growing every year but Nepal's share in such trade is significantly small. The country's exports so far have been mainly concentrated to India although it holds tremendous potential in diversifying its export destinations. A large number of people, mainly in the hilly regions of western Nepal, are engaged in the collection of MAPs for their livelihood. But people in these areas are still below poverty line. Therefore, if commercialization is promoted, these sectors will develop well and can contribute immensely in uplifting the socio-economic status of those people. Different laws, regulations, plans and policies put in place by the Government of Nepal have also encouraged the development of this sector. However, implementations of those plans and policies have not been effective.

Role of biotechnology

- **Research and Commercial technology**

Issues regarding inadequate supply of MAPs and essential oils can be solved by adopting modern technologies and methodologies. Adoption of commercial technology based on micro propagation like Bioreactor based propagation of plants can increase the rate of multiplication and growth of cultures and reduce the space, energy and labor requirements in conventional

micro-propagation. Development of disease-free and stress tolerant plants, understanding the molecular biology of plants, identification of molecular markers to determine different varieties of medicinal plants, using genetic engineering tool to produce high quality plantlets should be encouraged and practiced. The integrated approaches of plant culture systems will provide the basis for the future development of novel, safe, effective, and high-quality products for consumers.

- **Adoption of Genetic Transformation Technology and Production of Transgenic Plants**

  Genetic transformation technology has been proved to be a powerful tool for the production of plants with desired traits. It promises to overcome some of the substantial agronomic and environmental problems that have not been solved using conventional plant breeding programs. Similar success could also be achieved in medicinal plants, which in turn could be used for the enhancement of secondary metabolite content which will enhance the quality and quantity of extracts for commercial production. For the production of secondary metabolites establishment of cell lines capable of producing high yields of secondary compounds should be done.

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- **Processing methodology/ commercialization**

  The government should facilitate the transfer of modern and relevant technology for processing. Technology transfer should consist of both hardware and software components

  Traditional extraction method of essential oils like steam distillation, fractional distillation are the methods most widely used now-a-days. However, adoption of new techniques is valuable for commercial production of essential oils and for further purification using different chromatographic techniques for the production of value added products. Promoting this technology in the pivot scale and producing in a large quantity will provide enough quantity of quality products for finished products of medicines, perfumes, food industries.

- **Industry development and poverty alleviation**

  Fostering awareness on poverty issues and initiation towards industrial development will maintain the decreasing trend of poverty reduction and will provide employment to 300,000 families who are engaged in medicinal herbs collection in 58 districts and another 100,000 families who can easily join the herbs collection jobs when opportunities arise. Therefore, the sector has the potential to contribute more to poverty alleviation as it provides employment in remote areas, although these workers will need training.

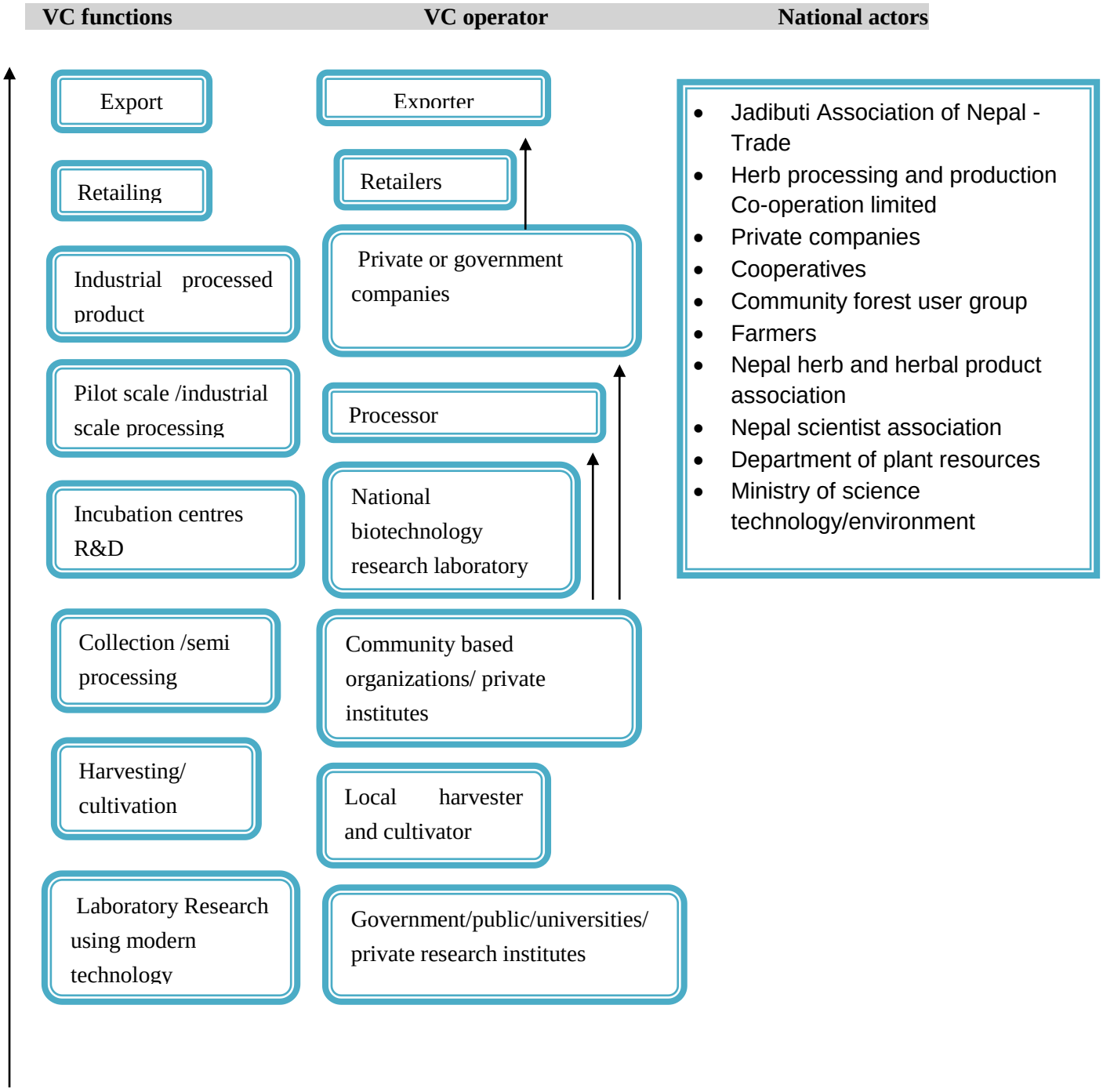
- **Training:**

  More awareness programs should be conducted for stakeholders to help them understand the importance of ensuring quality and how that could have a positive backward linkage in their incomes. Awareness and training programs on collection techniques should be undertaken in a massive scale. Such programs should target the real beneficiaries such as collectors who are directly engaged in the collection of MAPs

- **Conservation:**

  Though molecular level conservation is taking place in national institutions (NARC), detailed information on this is not properly disseminated to researchers and academicians. Initiation of molecular level conservation through maintenance of Gene Database (Gene bank) and use of techniques like DNA Barcoding at institutional level (recognized university laboratories) would help to relay information and would also encourage young researchers to undertake such activities. This in turn could create new employment opportunities for young researchers working in this field. Also *ex-situ* conservation (nurseries) should be further promoted by specifying the region for particular herbs. Cryopreservation is also the best way for the conservation of plant species.

5.3 Recommended Value chain



6 References

1. Anon, 2002. Assessing the impacts of commercial captive breeding and artificial propagation on wild species conservation. Cambridge IUCN/SSC Workshop: 7 (9-12)

2. Bhattacharya, A.K., Sekhar, K. and Yogesh, K., 2003. Marketing of certain cultivated Medicinal and aromatic plants with special reference to Madhya Pradesh, India. *Journal of Non-Timber Forest products* 10(3/4): 163-171

3. Dutta, I.C. & Devkota, K.P., 2001. Antibacterial activity of commercially traded herbs used in traditional medicine in communities of Doti district. Tribhuvan Universiy, Institute of Forestry, Pokhara, Nepal

4. Edward, D.M., 1996. Non- timber Forest products from Nepal: Aspects of the trade in Medicinal and Aromatic Plants. FORESC Monograph 1/96: Forest Research and Survey Center. Ministry of Forest and Soil Conservation (MFSC), Babarmahal, Kathmandu, Nepal

5. Hasan M. K., Gatto P., Jha P.K., 2013. Traditional uses of wild medicinal plants and their management practices in Nepal- A study in Makwanpur District. *Int. J. Med.Arom Plants*. 3(1): 102-112

6. Karki, M.B., 2000. Commercialization of Natural Resources for sustainable Livelihoods: the case of forest products. Sectoral, Paper presented at the International conference on Growth, Poverty Alleviation and Sustainable Management in the Mountain Areas of South Asia. German Foundation for International Development (DES) and ICIMOD

7. Malla, S.B. and Shakya, P.R. 1984. Medicinal Plants. In: Majupuria, T.C. (editor). *Nepal Nature's Paradise*. White Lotus Co. Ltd. Bankok, Thailand: 261-297

8. Mtui Y. S. G., 2011. Status of biotechnology in Eastern and Central Africa. *Biotechnology and Molecular Biology Review* 6(9):183-198

9. Schippmann U., Leaman J. D. and Cunningham A. B., 2002. Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity: Global Trends and Issues – FAO

10. Sharma U., 2007. Medicinal and Aromatic Plants: A growing commercial Sector of Nepal. Report. 1-6

11. Shrestha, T.B. and Joshi, R.M. 1996. Rare, endemic and endangered plants of Nepal.WWF Nepal

12. Shrestha B., 2003, Scientific research in Nepal: Where we are, *Himalayan Journal of Sciences* 1(1): 8-9

13. WHO, 2003. WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants- World Health Organization, Geneva

Reports and policies

1. Economic Survey, Fiscal Year 2014/15, Government of Nepal, Ministry of Finance, 2015
2. NEPAL LIVING STANDARDS SURVEY, 2010/11, STATISTICAL REPORT VOLUME TWO, CENTRAL BUREAU OF STATISTICS, National Planning Commission Secretariat, Government of Nepal, November 2011
3. Biotechnology Policy, 2006
4. Sharma, U.R., K.B.Malla and R.K.Uprety., 2013. Conservation and management efforts of medicinal and aromatic plants in Nepal. Banko Janakari. 23(1):3-11
5. National State-of-the-Art Report on Biotechnology for Nepal, 2008. Nepal Academy of Science and Technology (NAST), Khumaltar, Lalitpur, Nepal
6. Department of plant resource s(DPR),2015. Bul. Dept. Pl. Res. No. 37. DPR, Babarmahal, Nepal
7. Medicinal and Aromatic herbs stakeholders' directory, 2014. Jadibuti Association of Nepal

7 Appendices

7.1 Interviews

On interviewing different stakeholders, they demonstrated how policies are sensitive to the present agenda and demands.

Dr. Sangeeta Shrestha (Chief, Molecular Biotechnology, NAST)

Nepal has more plants of medicinal importance than reported in different articles. We have to understand that diverse plants of medicinal importance are our assets and we could utilize them for the improvement of people's lives and economic development. In the present situation, it is worrying that such knowledge and plants are about to disappear and we need to take an immediate step like reviewing the policies more with genetic level research as wells as marker level analysis, for which government should allocate more budget towards research and development. Promotion of foreign collaboration towards working on unexploited medicinal herbs and adoption of new technology will reduce the brain drain problem. There should be proper monitoring of fund and good incentive in terms of wages for the scientific community.

Dr Bindeshwar Prasad Shah (Chief, Biotechnology Unit, NARC)

There is a general perception of people that biotechnology is a costly business, but in reality it is not true. The field is new and its implication needs more awareness among all. For the growth of biotechnology, there should be creation of dedicated funds and the government should practice preparation of strategic plan-research priority setting. Development of national biotechnology center, an integrated institution of excellence with interdisciplinary approach would be a major achievement. Promotion of R&D and development of guidelines regarding bio-safety for transfer of biological materials (import and export) should also be done. Development of provisions on easy access and benefit sharing regarding biological resources among stakeholders is necessary. Incentives should be given to production units by tax relaxations on equipments, consumables and raw materials. It is also advised to formation an advisory committee of experts with representation of various stakeholders.

Dr Mukund Ranjit (President, Nepal Biotechnology Association)

Biotechnology should be the major concern of today’s generation for the development of nation but this is not practiced till date in Nepal. Policy formulation has encircled different focus areas but they are limited to paper, and the implementation part is lacking. Obsolete equipments and lack of resources is a major issue. No good operational fund is allocated for research and development. The preliminary research activities are being practiced since years back but due to lack of co-ordination between scientific communities and government, some of the research output is confined only to

paper and some are not. Also these results are not easily accessible to everyone Due to all these constraints and lack of research platform, Nepal is facing brain drain. In order to avoid this, establishment of incubation centre will prove a great incentive for stepping up research towards pivot scale and industrialization and this will shape the way towards economic development and employment. Ministry of science technology and environment should take an initiative towards the development of central laboratory/ technology centre acting as a reference laboratory for developing standard methodology and creating a coordinating environment among different private, public and government level research institutes. Nepal should realize the importance of MAPs and its potential in nation's development.

Dr Sameer Mani Dixit (Country Director, Centre of Molecular Dynamics (CMDN))

Ministry of Science Technology and Environment, Nepal plans to establish a national biotechnology centre to promote research and development in agriculture, health, environment and industry. By setting up this centre, Nepal hopes to begin the path towards economic development. But without a proper government entity in place you cannot do that. Research funding is not the only issue but lack of dedication and vision among researchers and also among concerned authorities is equally worrying. Lack of collaborations and co-ordination among scientific communities and also among government and scientific communities is there, which somehow deviates people from their responsibilities. But we should not forget that we are far ahead of where we were 10 years back. To maintain this and push the present status of research and development in forward direction, MoSTE should take an initiation and call for action for the development of central research laboratory which will include all disciplines including biomedicine, microbiology, genetics, natural resource research etc

Dr. Janardhan Lamichhane (Professor, Biotechnology, Kathmandu University)

Nepal has made considerable progress in the institutionalization of S&T institutions and in articulating science and technology policies over the last decade. NAST has repeatedly enunciated a number of policy frameworks for applying S&T for development. Despite investing in R&D as a proportion of GDP the linkages between different actors in the national S&T system has been quite dismal. The main problem, behind Nepal lagging in R&D, has been the gap between the policy and its implementation. The main constraint in higher education in S&T has been the lack of funds to upgrade physical facilities and create appropriate conditions for long-term R&D programmes. Coupled with this there are the declining standards in both teaching and research. The national effort in R&D is still quite low compared to other neighbouring countries in the region.

7.2 Field photos