THE STATE
OF THE WORLD's
FOREST GENETIC RESOURCES

COUNTRY REPORT

NEPAL

This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

Country Report on the State of Forest Genetic Resources

Nepal

Government of Nepal
Ministry of Forests and Soil Conservation (MFSC)
Singh Darbar, Kathmandu

January 2013

Country Report on the State of Forest Genetic Resources-Nepal

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(.....)

Foreword

This Country report entitled "Forest Genetic Resources of Nepal" is prepared as part of "The State of World Forest Genetic Resources" and demonstrates national commitment toward the implementation of the Multilateral Environmental Agreements including the Convention on Biological Diversity.

Over exploitation of selected tree species and habitat fragmentation due to unplanned development activities are some of the major drivers of the depletion of forest genetic resources. This depletion is further aggravated by the indiscriminate introduction of exotic species of flora and unauthorized of use of germplasm.

This report is the continuation and summarization made on the state of forest genetic resources of Nepal. It documents the current status of forest genetic resources and the conservation initiatives at local and national level. The report also lays the foundation for sustainable management of forest resources in Nepal that contributes to biological diversity conservation, environmental integrity and food security. Besides, strengthening the awareness on the importance of sustainable use of Nepal's forest genetic resources, the report forms the basis for the integrated planning and management of forest genetic resources from the grass root to national levels.

Drafting and preparation of this country report was led by the Ministry of Forests and Soil Conservation and was guided by the national committee consisting of representative of various national agencies. This committee has completed its task on time. I thank the national committee members for this accomplishment. Technical and financial assistance provided by FAO Nepal toward the preparation of this report is greatly acknowledged. Similarly, I would also like to extend my appreciation to Professor Ram Prasad Chaudhary, Professor Krishna Kumar Shrestha, Dr. Annapurna Nand Das, Mr. Bajra K. Yadav, Mr. Resham Dangi, Dr. Rajendra K.C., Mrs. Apsara Chpagain and Dr. Albert Nikiema of FAO Rome for reviewing the report and providing critical comments.

This report has tried to capture the wide range of knowledge of various stakeholders with whom intensive consultation was held. I highly appreciate their contribution and wisdoms.

The national focal point on Forest Genetic Resource (FGR) Nepal Mr. Hem Lal Aryal and working group members Mr. Sagar Rimal, Mr. Deepak Kharal, Dr. Maheshwar Dhakal, Mr. Suraj Ketan Dhungana and Sushil Bhandari deserve special appreciation for their hard work in order to complete this report on time. This report would not have come to this stage without the

creative and expert contribution from FAO consultant Dr. Narendra Bahadur Chand. Finally, I would like to thank all of those involved in preparing this report.

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Acronyms and Abbreviations

ABS	Access to Biodiversity and Benefit Sharing
AI	Autonomous Institution
APAFRI	Asia Pacific Association of Forestry Research Institutions
BPP	Biodiversity Profile Project
BSO	Breeding Seed Orchard
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CFM	Colloborative Forest Management
Danida	Danish International Development Assistance
DFO	District Forest Office
DFRS	Department of Forest Research and Survey
DNPWC	Department of National Parks and Wildlife Conservation
DoF	Department of Forests
DPR	Department of Plant Resources
FGR	Forest Genetic Resources
FORTIP	UNDP/FAO Regional Forest Tree Improvement Project
FUG	Forest User Group
GDP	Gross Domestic Product
GO	Governmental Organization
GoN	Government of Nepal
HDI	Human Development Index
HH	High Himalaya
HLFFDP	Hills Leasehold Forestry and Forage Development Project
HM	High Mountain
ICIMOD	International Centre for Integrated Mountain Development
INBAR	International Network on Bamboo and Rattan
ILO	International Labour Organization
INN	International Neem Network
IPPC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature
Km^2	Square kilometre
MFSC	Ministry of Forests and Soil Conservation
MM	Middle Mountain
MPFS	Master Plan for Forestry Sector
NARC	National Agriculture Research Centre
NAST	National Academy of Science and Technology
NBS	National Biodiversity Strategy
NCS	National Conservation Strategy
NFI	National Forest Inventory
NGO	Non-government Organization
NP	National Park
NPWCA	National Park and Wildlife Conservation Act

NWFP	Non-wood Forest Products
PA	Protected Area
SAARC	South Asian Association for Regional Cooperation
TISC	Tree Improvement and Silvicutlure Component
TMJ	Tinjure Milke Jaljale
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TU	Tribhuvan University
UNDP	United Nations Development Programme
VDC	Village Development Committee
WLR	Wildlife Reserve
WWF	World Wildlife Fund for Nature Conservation

Section I

Executive Summary

Genetic diversity provides the fundamental basis for the evolution of forest tree species and for their adaptation to change. Conserving forest genetic resources, therefore, is vital to protect the unique and irreplaceable resource for the future. Forest Genetic resources management can be effective only if treated as an integral element of overall sustainable forest management. Conservation concerns should be integrated into broader national and local development programs, such as national forest programs, rural development plans and poverty reduction strategies, which promote cooperation among sectors. However, there is no consolidated global picture on the status and trend of forest genetic resources, and lack of sufficient study to identify the rate of genetic diversity loss. These limit the capacity of country and international community to integrate the appropriate management stategies and programme about the conservation of the forest genetic resources into overall cross-cutting policies. The Commission on Genetic Resources for Food and Agriculture (CGRFA) of FAO acknowledged the urgency of conserving and sustainable use of forests genetic resources. With support of FAO's Committee on Forestry, the CGRFA has requested that *The State of the World's Forest Genetic Resources* (SoW-FGR) be prepared for presentation in 2013. The primary source of data and information for the preparation of the SoW-FGR will be Country Reports on Forest Genetic Resources.Considering these facts Report on Forest Genetic Resource of Nepal has been prepared. Forest genetic resources in this report primarily refer to the tree genetic resources.

Nepal is endowed with rich biodiversity. Wide altitudinal variations and diverse climatic conditions have made Nepal one of the ecologically most diverse countries in the world. Nepal comprises only 0.09% of the global land area, but possesses 2.7% of the world’s recorded flowering plants. More than 6,500 species of flowering plants, 28 species of gymnosperms, 853 species of bryophytes and 534 species of pteridophytes have been listed in the country.

Altogether 118 ecosystems and 35 forest types have been recognised and are used in forestry sector of Nepal. About 400 tree species have been recorded to date. Extension of area for agriculture production, establishment of new settlement, and various types of development activities have lost the forests and unique habitat, threatening the biodiversity of the country. At the same time, over exploitation of selected tree species, absence of sustainable management practices, inappropriate application of silvicultural techniques, and fragmentation of forest land are major causes for the loss of genetic diversity of the forest tree species. Information on forest types, genetic diversity and ecosystem become obsolete therefore needs reassessment. To enhance assessments of the state of diversity of forest genetic resources and understanding the evolutionary factors determining the genetic constituents of the important forest tree species and their population, various capacity building activities need to be undertaken.

Policy tools and instruments are essential along with preventive measures to address the loss of genetic diversity of tree species. To this end, government has prepared National Biodiversity Strategy (NBS), 2002 which highlights an overview of Nepal's biodiversity along with major achievements, gaps and future strategies. NBS emphasized on inventory of the species in the protected areas and throughout the country. A species conservation plan that focuses on the keystone species is pressed concerned of the NBS. Following NBS, numerous policies such as wetland, rangeland etc. have been developed and implemented accordingly. Forest Act 1993 and Forest Regulation 1995 have provision to protect species which are likely to be threatened. Other than national policies, government is adhering international treaties such as CITES.

Significant efforts have been made to conserve forest genetic resources in their native environment. Broadly, Nepal is implementing *in situ* conservation within and outside the protected area (PA) systems. Various types of protected areas have been established to implement *in situ* conservation. However, it is often claimed that PAs do not adequately represent all parts of physiographic regions, altitudinal zones and eco-regions. In addition to PAs, *in situ* conservation has been implemented adopting various forest management regimes. These include community forests, government-managed forests, protection forests, leasehold forests, collaborative forests and religious forests. Within these management regimes, the government implements various *in situ* conservation programmes. The most prominent programmes are establishment of seed stand, botanical gardens and gene conservation areas for threatened and economically important species. However, many threatened species and ecosystems are still away from any *in situ* conservation programme. Therefore, focused programme on ecosystems and species conservation outside PAs (community based forestry management, promotion of on-farm conservation, *in situ* conservation of specific species etc.) is desirable.

Besides *in situ* conservation through PAs, on farm conservation has emerged as a new approach in conserving FGR. Considerable numbers of species are maintained in the farm as a part of subsistence farming. The role of these tree species in biodiversity conservation is inevitable. However, in absence of incentive policy, on farm conservation of tree species could not maintained. Other means through which *in situ* conservation is taking place is by establishing seed stands and gene conservation areas. In spite of government's efforts, no significant improvement has been observed in these *in situ* conservation areas. This is mainly because of high human pressure and high economic value of these species.

Besides the conservation of forest genetic resources in their native habitats, efforts are being made towards *ex situ* conservation. *Ex situ* conservation in Nepal basically focuses on conventional approaches viz. tissue culture, Breeding Seed Orchards (BSOs), botanical gardens, arboretum and gene bank. The required infrastructure capacity of the country for desired level of *ex situ* conservation is very limited. Only a few government agencies are equipped with tissue culture facility. In recent years, some private institutions equipped with laboratory have been established facilities to enable biotechnology related research in the country. The government

could not pay adequate attentions towards sustaining existing *ex situ* conservation sources, owing to insufficient human and monetary resources. To safeguard the existing *ex situ* conservation collections, efforts are underway to involve concerned stakeholders in their use and management. The government has been attempting to entrust the management responsibility of orchards to the local community by allowing the community to receive benefits from them. Despite the handing over to the community, sustainability of the orchards could not be ensured.Weak linkages have failed to create incentive for sustainable management of orchards. There are numerous constraining factors for development of *ex situ* conservation, the most noticeably includes lack of baseline information, insufficient staff, limited resource available for conservation activities, lack of gene bank laboratory, and e*x situ* conservation receives relatively lower priority than the other programs. In addition, there is a lack of comprehensive inventory regarding the status of forest species.

Genetic improvement is essential to improve the supply of forest products and sustain the genetic diversity of forest resource. In this regard, the government implements numerous activities including establishment of BSOs, Seed Stand and Provenance Trials. Also, genetic improvement has been attaining through improving in seed distribution mechanism. Nepal has adopted a decentralised seed production and supply system, in which seeds are produced and supplied through the local cooperatives. This system is considered a novel approach in Nepal. However, quality seed supply could not be maintained because of weak national policy and legal framework to regulate tree seed supply system. Many private seed suppliers imports seeds from India, without any documentation of genetic quality. The link between seed cooperatives and private seed suppliers is relatively weak.

Various institutions are involved in the FGR related studies. Institutions such as DoF, DNPWR, DPR and DFRS have been engaged in carrying out research and implementing FGR conservation at the field level. DPR is equipped with laboratory for tissue culture and other phytochemical studies. In addition, various academic institutions runs forest genetic-related academic courses and are equipped with laboratory facilities. Many international organisations are also involved in research. Despite these research initiatives, the FGR themes are not sufficiently addressed in the educational curricula among institutions of higher learning. Especially the institutions are lacking with updated technology and courses. In order to improve country capacity to deal with FGR issues, there is need for an increased emphasis and more articulated teaching of these especially at the university level.

FGR conservation has been guided by series of policies over last ten years. Government has formulated and enacted various plan, policies, strategy and laws associated with FGR conservation. Nepal has also signed and ratified various international treaties, agreements and conventions associated with conservation of forest genetic resources. Lack of information and complexity in matching international treaty and agreement in national perspective are some of the constraints.

Nepal has been a participant of various regional, sub-regional forest genetic resources network. These collaborative efforts expected help greatly in improving the country's capacity in conservation and sustainable management of FGR. Although Nepal has been participating in number of regional and sub-regional networks, the country has not been able to receive benefit, to a large extent, from the networking, except in some cases in terms of technology development and information sharing. Few international programmes have been implemented for forest genetic resources in the country. It is widely realised that the state of diversity in terms of species, genetic and ecosystems has not been comprehensively studied. The existing knowledge or information so far on the diversity status are obsolete and are briefly studied. Only few studies have been undertaken diversity studies at the genetic level, using advance technique such as molecular techniques. Therefore, development of scientific protocols and standard marker systems for diversity assessment and their implementation for at least major tree species is desperately needed.

FGR of the country will contribute to food security, poverty alleviation and sustainable development. Integration of forests into agricultural systems provides a range of benefits, in terms of restoring or sustaining soil fertility through composting and resulting sustainable agriculture production. Forest provides fodder and animal bedding to livestock which in turn provide manure to the agriculture and meat and milk to the households. Many species of trees laying on farms as well as forest trees and associated understorey shrubs and grasses, are used as food when other food sources are scarce. It has been estimated that 80 percent of the fodder requirements of the country is supplied from the forest trees this includes both from private forest and national forest.

Despite many efforts, local people have not been able to capture adequate benefits from the forest genetic resources to ensure its further conservation. In order to overcome shortage of forest resources, it is imperative to create direct and tangible benefits to the local people by alternatives and to creating ownership over forest resources. With this respect, access to FGR and equitable and fair sharing of benefits arising from the utilization of forest genetic resources is necessary. Nepal has subscribed to various international agreements relevant to access and benefit sharing from FGR.

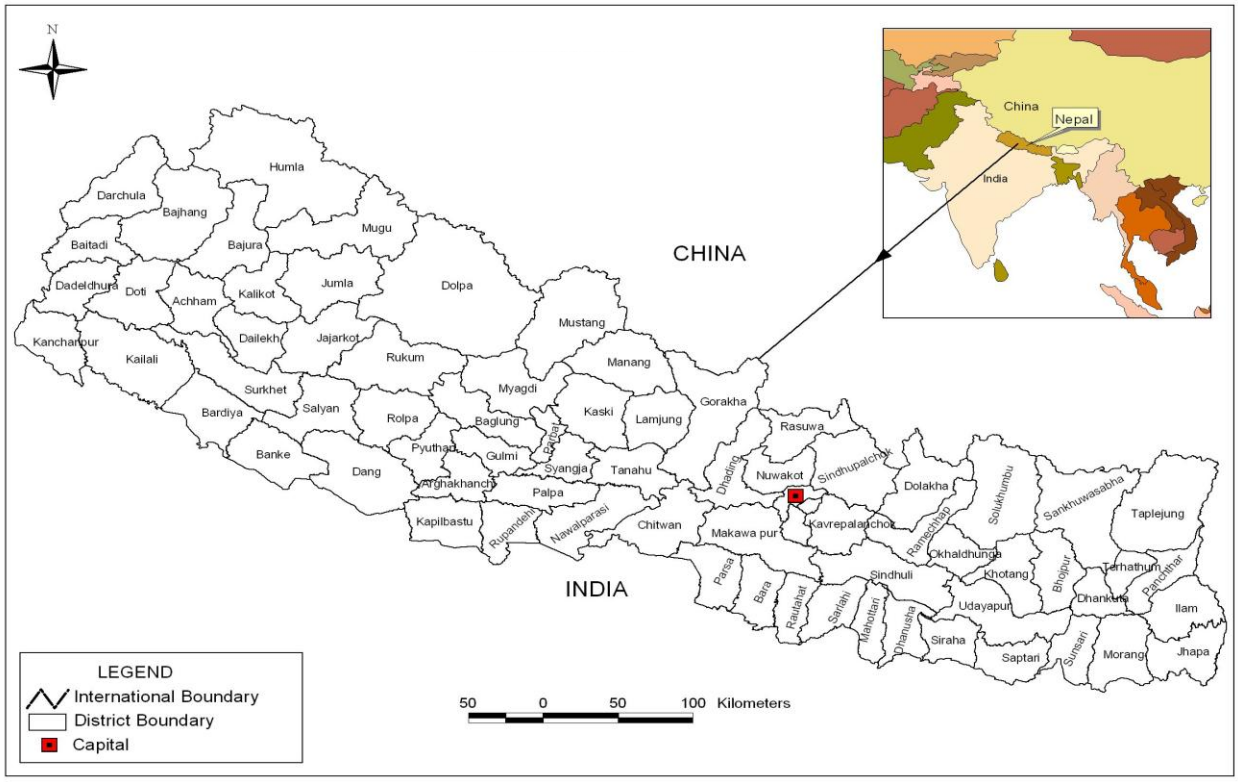
Section II

Introduction to Nepal and its Forestry Sector

1. Political and Administrative Features

Nepal is a landlocked country, which is situated along the southern slopes of the central Himalayas between India on its south, east and west, and the Tibetan Autonomous Region of the Peoples' Republic of China to the north (Figure 1). It extends over a length of 885 km from east to west, and the width varies from 145 km to 241 km north to south, and lies between latitudes 26^0 22' to 30^0 27'N and longitude 80^0 4' to 88^0 12'E. Nepal has a total land area of 147,181 km^2. Being mountainous, almost 86% of the land mass of the country is covered by rolling hills and high mountains, this includes snowcapped mountains as well, and remaining 14% is flat land called the Tarai. The altitudinal variation ranges from 70 m above mean sea level at Kechana Kalan located in eastern Tarai district of Jhapa to 8,848 m, the highest point of the world, Mount Everest. Administratively, Nepal is divided into five development regions, 75 districts, 58 municipalities and 3915 village development committees (VDCs) (GoN, 2011).

Figure 1. Country map of Nepal

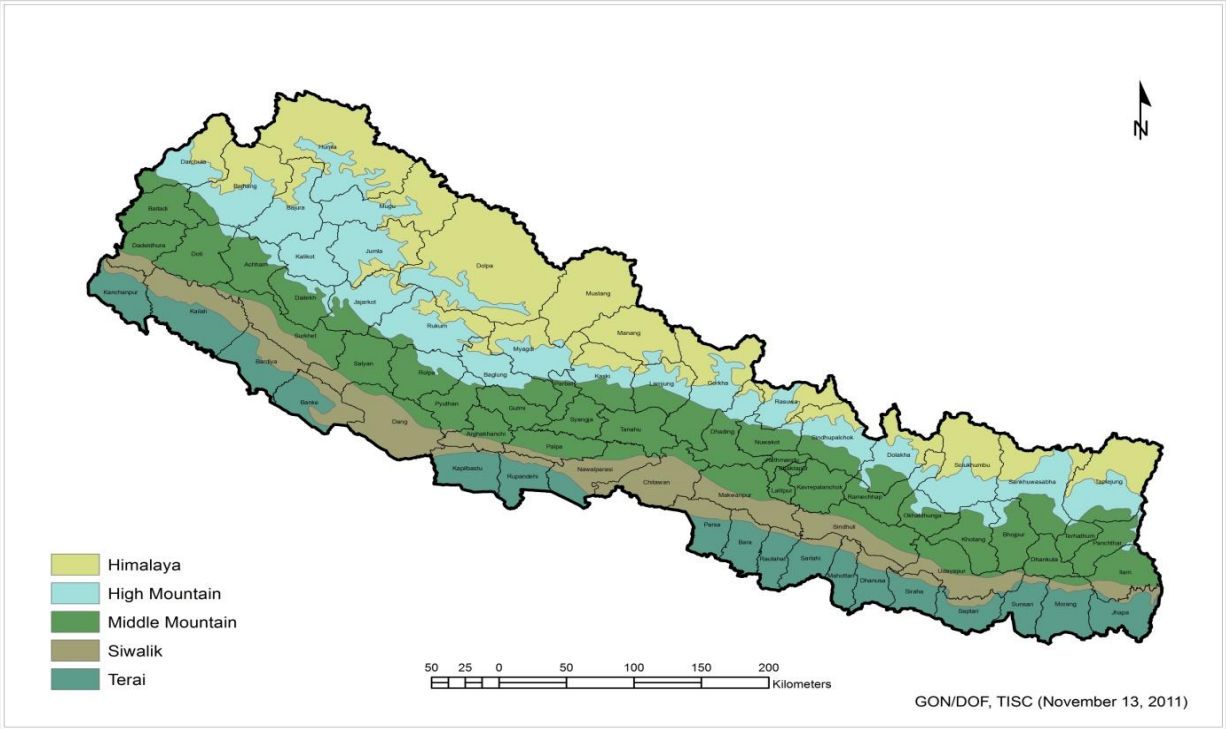


2. Physiographic and Climatic Features

Physiography

Physiography refers to the study of surface landform characteristics. For the sake of convenience, the physiography of Nepal has been divided into five broad agro-ecological zones, viz. Himalaya, High Mountain, Middle Mountain, Siwaliks and Tarai on the basis of river, relief, structure, altitude and geographical distribution (Figure 2). The country is mainly drained by the three major river systems namely Koshi, Gandaki and Karnali from east to west, respectively.

Figure 2. Physiographic regions of Nepal



High Himalaya

The High Himal is in the northernmost part, lies mostly above 4000 m altitude that stretches from the east to the west of the country, where hundreds of snow-capped peaks are found. There is a maximum relief, steep slope and rugged terrain in this belt. The cultivated areas of this region are the inner Himalayan valleys and some southerly aspects of mountains.

High Mountain

The intervening mountainous country between the Himalaya and the Mahabharat constitutes the Midlands traditionally known as 'Pahad' (TISC, 2002). The Midlands have diverse geological and geographical structures, which have resulted steep and dissected landforms and topography.

The altitudinal range of the Midlands is 600 to 3,500 m. It also comprises of high valleys with dense populations like Kathmandu and Pokhara.

Middle Mountain

The Middle Mountain lies north of the Siwaliks and occupies the central region of the country. The region is also called the Lesser Himalaya with elevations 1,500 to 2,700 meters along the crest, paralleling the much higher Great Himalaya range. This range also parallels the lower Siwalik (Outer Himalaya) to the south. Agriculture is intensive in these parts of the country and farmers have made terraces on the hillside and often up to the tops of high hills. Forests have been severely degraded in these regions and the rate of soil erosion is high. The area is rich in water resources and all river systems which originated from Himalaya converge in these region.

Siwaliks

The Siwalik Hills or Churia are the southernmost and geologically youngest east-west mountain chain of the Himalayas. The Siwaliks crest at 600 to 1,200 metres, have many sub-ranges and it cuts through at wide intervals by large rivers flowing south from the Himalayas. Smaller rivers without sources in the high Himalayas are more likely to detour around sub-ranges. Southern slopes have networks of small rills and channels, giving rise to ephemeral streams during the monsoon and into the post-monsoon season until groundwater supplies are depleted. In many places, the two ranges–Mahabharat and Churia are adjacent but in other places structural valleys 10–20 km wide separate them. These valleys are called Inner Tarai and include Chitwan, Dang-Deukhuri and Surkhet.

Tarai

The Tarai region is a flat plain in the south running from east to west. It is the plain land of altitude below 600 m referring to plains from the edge of the Siwaliks south to the Indian border. North of the Tarai rises the Bhabhar, a narrow but continuous belt of forested alluvial fans washed down from the Siwalik. A permeable mixture of of gravel, boulders, and sand enables the water table to sink 5–37 m deep. The Tarai zone below the Bhabhar is composed of less permeable layers of clay and fine sediments, bringing groundwater to the surface in springs and wetlands. The Tarai is crossed by large perennial Himalayan rivers like Mahakali, Karnali, Gandaki, Narayani and Kosi that have each built alluvial cones covering thousands of square km below their exits from the hills. There are also medium rivers such as the Rapti rising in the Mahabharat Range and smaller seasonal rivers originating in the Siwaliks. All these have deposited alluvial cones. This deposition process creates multiple channels with shallow beds, enabling massive floods as monsoon-swollen rivers overflow their low banks and shift channels.

Climate

The generalization of climatic condition of Nepal is too difficult. It is varied within same altitude and latitude. This variation is resulted by the physical diversity (altitudinal variation) of the country. In addition, the orientation of mountain ranges, deep valleys, slopes and aspects are major factors creating a number of micro-climatic regimes within short distances from south to

north. The summer monsoon exterts the most important influence on climatic variation, and consequently the country as a whole is characterized by four distinct seasons - winter (December to February), spring (March to May), summer (June to September) and autumn (October to November).

The Himalayas comprise sub-alpine and alpine climates. The inner Himalayan valleys have a rather dry and cool climate. The average daily temperature fluctuates between 9 to 10^{o}C during June/July. The annual rainfall varies from 140 mm in the west to 900 mm in the east.

The mountain region is characterized by temperate climate where the average daily temperature fluctuates between 2 to 17^{0}C during December/January and between 13 to 27^{o}C during June/July. The average rainfall varies from 1000 mm in the west to 2800 mm in the east, with more winter rain in the west than in the east. On the other hand, the lowlands, Tarai and Siwaliks regions have similar sort of tropical and subtropical climate, respectively. The average daily temperature fluctuates in lowlands between 7 to 24^{o}C during December/January and between 24 to 41^{o} C during June/July. The rainfall ranges from 600 mm in the west to 1300 mm in the east, with winter rain occurring in the west.

In recent decades, Nepal has witnessed the effects of climate change. In general, the country has experienced the mean annual increase of maximum temperature by 0.06°C and precipitation by 30 mm (Karki et al., 2009; Practical Action, 2009).

3. Human population and trends

According to 2011 census, Nepal's total population is approximately 26.6 million of which 83% resides in rural areas. The current population is significantly bigger than earlier but the rate of population growth is lesser than previous year (see Figure 3). The population growth rate reached unto 2.5 percent during 1950s (see Figure 4). However, currently the country has been experiencing population increase at the rate of 1.40% annually (between 2002 and 2011). The average population density is 181 per km^2 with the highest density (392 per km^2) in the Tarai, medium density (187 per km^2) in the Mid Hills and the least density is found in the High Mountain region (35 per km^2).

Figure 3. Population size according to different census

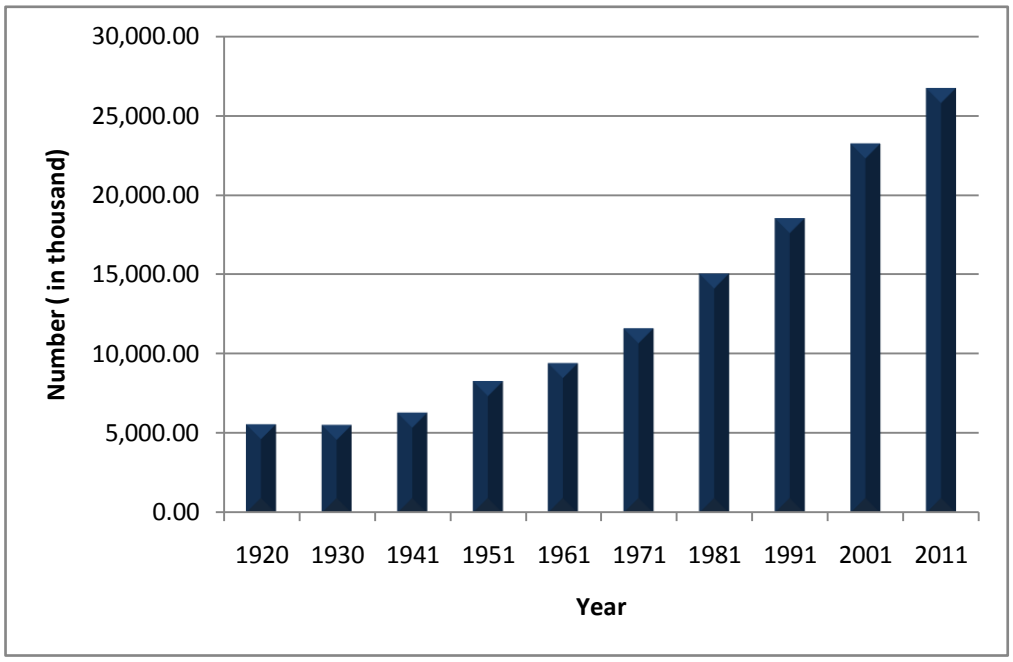
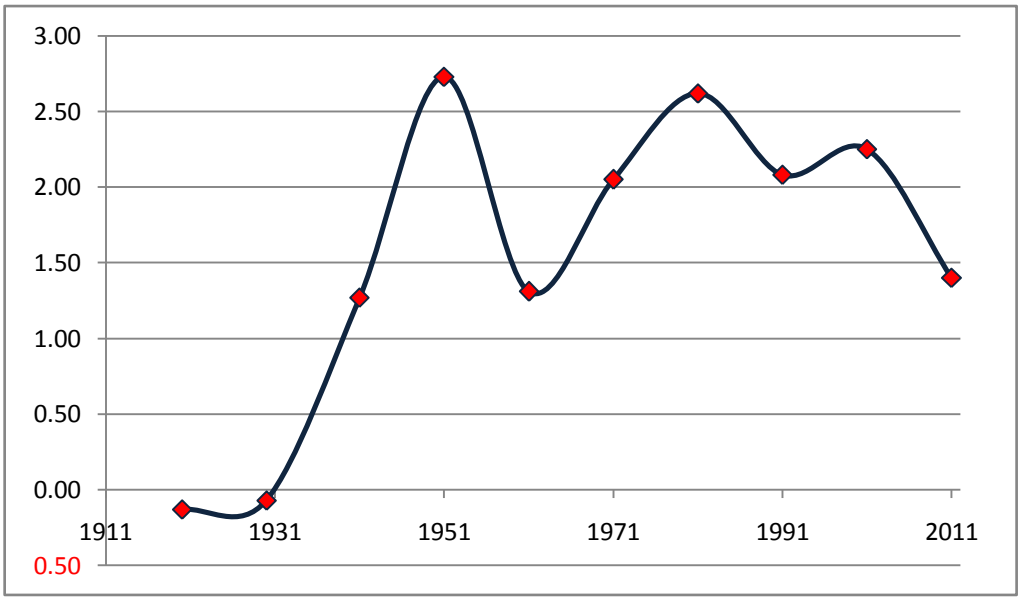


Figure 4. Trend of population growth



Source: CBS (2011)

4. Human Development Index

Human Development Index (HDI) is a summary measure of human development. It measures the average achievements in a country in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. The United Nations Development Programme in 2010 reported that between 1980 and 2010, Nepal's HDI rose by 2.4% annually from 0.210 to 0.428 today, which gives the country a rank of 138 out of 169 countries. The HDI of South Asia as a region increased from 0.315 in 1980 to 0.516 today, placing Nepal below the regional average.'Multidimensional' poverty, gender gaps, rising inequality are identified as Asian region's big challenges.

5. Forest and forest resources

Forest is the most important asset that provides the basic necessities and one of the major sources of Nepal's income. The Forest Act, 1993 defines forest as an area, which is fully or partially covered by trees or shrubs. The Department of Forest Research and Survey (DFRS) carryout inventory periodically and updates forest statistics. Recent inventory using satellite images reports that forest area is 4.27 million hectares (29%), shrub land area is 1.56 million hectares (10.6%), together with trees and shrubs covered land, total forest area is 5.83 million hectares or 39.6% of the total land area of the country (DFRS, 1999).

Nepal experiences large variations in climatic and physiographic conditions, which have endowed with a wide range of ecological zones and resulted well-off in wild flora. The country is rich in genetic resources of plant species. Bhuju et al., (2007) have reported well-off about 6,666 species of flowering plants in Nepal. According to Vetaas & Chaudhary (1998), Nepal shares more than 2% of world's flowering plants, while its land area comprises less than 0.1%.

6. Forest Types

Forest types of Nepal are very diverse with different species of flora. Stainton (1972) classified 35 forest types. These forest types are categorized into ten major groups (GoN, 2002).

Tropical Forest (below 1,000 m): This forest type is predominantly composed of *Shorea robusta* occurring in the southern parts of Nepal. *Acacia catechu*, *Dalbergia sissoo* forests replace *Shorea robusta* forests along streams and rivers.

Subtropical Broadleaved Forest (1,000-2,000 m): *Schima wallichii- Castanopsis indica* forests are found in central and eastern Nepal.

Subtropical Pine Forest (1,000-2,200 m): *Pinus roxburghii* forests occur particularly on the south-facing slopes of the Mid-hills and Siwalik.

Lower Temperate Broadleaved Forest: This forest type occurs between 2,000-2,700 m in the west and 1,700- 2,400 m in the east. *Alnus nitida*, *Castanopsis tribuloides*, *C. hystrix*, *Lithocarpus pachyphylla*, and several other species of Quercus are found in this forest.

Lower Temperate Mixed Broadleaved Forest (1,700-2,200 m): This type of forest is confined to north and west facing slopes, which especially include the Lauraceae family.

Upper Temperate Broadleaved Forest (2,200-3,000 m): *Quercus semecarpifolia* forests are widespread in central and eastern Nepal on south-facing slopes.

Upper Temperate Mixed Broadleaved Forest (2,500-3,500 m): This forest type occurs in central and eastern Nepal, mainly on north and west-facing slopes. Acer and Rhododendron are prominent species.

Temperate Coniferous Forest (2,000-3,000 m): *Pinus wallichiana*, *Cedrus deodara*, *Cupressus torulosa*, *Tsuga dumosa* and *Abies pindrow* forests characterize the temperate conifer forest type.

Sub-alpine Forest (3,000-4,100 m): *Abies spectabilis*, *Betula utilis*, and Rhododendron forests occur in subalpine zones, the latter in very wet sites.

Alpine Scrub (above 4,100 m): Juniper-Rhododendron associations include *Juniperus recurva*, *J. indica*, *J. communis*, *Rhododendron anthopogon*, and *R. lepidotum* associated with *Ephedra gerardiana*, and *Hippophae tibetana* in inner valleys.

7. Forest Types based on legislation

In Nepal, there are seven forest types defined by Forest Act, 1993 and those are:

- Government Managed Forests
- Protection Forests
- Community Forests
- Leasehold Forests
- Religious Forests
- Private Forests
- Collaborative Forests[1].

Community forestry has contributed to restoring forest resources in Nepal. In this approach, local users organized as Community Forest User Groups (CFUGs) take the lead and manage the resources, while the government plays the role of facilitator and technical back up. The advantages of community forestry include employment and income generation from forest protection, tree felling and log extraction, as well as non-timber forest products. Additional economic benefits are in the form of sustained wood fuel sources, which contribute more than three-quarters of energy needs to households. Improved forest management and cover also contribute to nature conservation.

The Hills Leasehold Forestry and Forage Development Project (HLFFDP) is helping to set up leasehold forestry groups that will eventually become village finance associations. The overall goal is to reduce poverty in the area by allocating leasehold forestry plots to poor families to enable them to increase incomes from forest products and livestock. Specifically the programme objectives are:

[1] This category is later on added by government from the directive in 2001

- improve household forage and tree crop production,
- improve household production of livestock, especially goats, sheep and buffaloes etc,
- provide access to microfinance institutions, and
- support the government's capacity to implement leasehold forestry in a gender-sensitive way.

Collaborative Forest Management (CFM) has been developed as a decentralized and participatory forest management modality, specifically for the Tarai region. It was believed that Community Forestry, a very successful modality in the hills and mountainous region of Nepal, could not be as successful as in hills to the Tarai. The social and biophysical settings of the Tarai are so different and complex that the hill's Community Forestry (CF) model are less effective to address the issues of Tarai Forest management and the distant users. First of all, the Tarai comprises of highly valuable forests that should benefit Nepal as a whole. Secondly, the market demand for commercial wood have made CF model very challenging in the Tarai. CFM addresses these issues of benefit sharing and distant users, while it also answers to the aspiration and policy of decentralization and devolution. The governing structure of CFM has incorporated all stakeholders, including village development committee and district development committee. Table 1 shows status of different community based forest management in the country.

Table 1. Community based forest management systems in Nepal

SN	Types	Total Areas (ha)	Number of FUG	Household Involved
1	Community forest	16,52,654	17,685	21,77,858
2	Leasehold forest	34,826	6,041	56,018
3	Collaborative forest	29,798	13 CFM plan	-
4	Buffer zone forest	5,07,667	4,088	1,20,210
	Total	2,224,945	27,827	23,54,086

Source: Department of Forests (2011)

8. Biodiversity in Nepal

The biodiversity in Nepal is supported by forest, rangeland, wetland and mountain ecosystems. To protect these ecosystems, the Government of Nepal has established four kinds of protected areas, and these are national parks, wildlife reserve, conservation area and buffer zone. There are eight national parks, five wildlife reserves and four conservation areas in Nepal. The national parks, wildlife reserves and conservation areas have occupied 10144, 2398 and 11742 sq. km areas, respectively. Nepal's biodiversity is a reflection of its unique geographical position and climatic variations. There are over 6,500 species of flowering plants, out of those, about 286 species of flowering plants are considered endemic to Nepal (Rajbhandari & Dhungana, 2011). A total of 118 ecosystems have been identified in different physiographic zones of Nepal. Out of

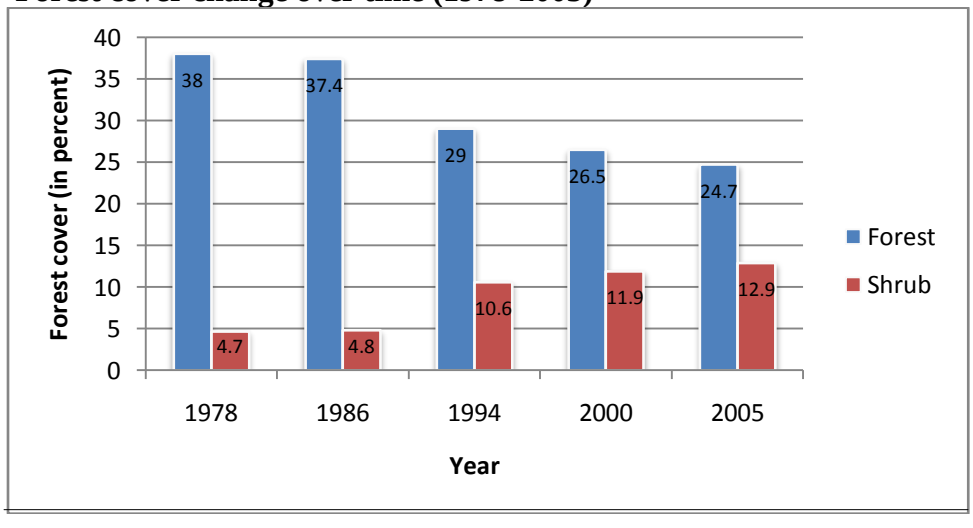
these ecosystems, 80 ecosystems are represented in present protected area system in Nepal (BPP, 1996).

The National Parks and Wildlife Conservation Act (NPWCA), 1973 and its associated regulations are the principal legal instruments that govern the management of protected areas in Nepal. The government has also brought forward Buffer-Zone Management Regulations, 1996 which provided local communities rights to manage the forests around the protected areas to fulfill their needs and at the same time maintaining the buffer-zone forests as security belt to conserve core protected areas by involving local communities.

9. Land-Use Change

The country has always experienced decline in forest coverage over time. However, the decline rate has been varying. Figure 5 shows that forest area has decreased to 29% in 1994 from 38% in 1978. The degraded forest converted into other land uses such as shrubland and agricultural land. The shrubland has increased from 4.7% in 1978 to 10.6% in 1994. The rate of forest area decreasing was 1.7% per annum during 1978 to 1994, whereas forest and shrubs together decreased at an annual rate of 0.5% during the same period. There has been no national inventory since 1994, hence the forest cover data are purely based on 1994 surveyed data. Forest coverage data for year 2000 and 2005 are based on the FAO's Global assessment which is carried out at five years interval. Data related even beyond 1994 indicate that forest has been declining; however, the rate of declining is relatively less than before. The inventory indicates forest coverage including shrub declined at the rate of 0.20 % annually between 1978 and 1994. On the other hand the decline rate has been found 0.18 % annually between 1994 and 2005. Shift in government policy towards community based management is associated with improvement in forest declining rate (Forestry Department, 2010; Gautam et al., 2004).

Figure 5. Forest cover change over time (1978-2005)



Source: Forestry Department of FAO (2010)

10. Forest based enterprises

Forest based enterprises traditionally served as a means of sustaining livelihood of rural people. In Nepal, there has been an increase in interest and efforts to develop forest based enterprises following the institutionalization of various community-based forest management programmes. Though there are some medium scale enterprises, their contribution to generating employment is small (ANSAB, 2009). Hence, focus is more on establishing small and medium sized enterprises. Various studies have also clearly shown the contribution of small and medium scale community based enterprises have generated employments and contributed to poverty reduction.

Forest based enterprises are broadly classified into micro, small and medium enterprises. Micro enterprises are very small and family based. The micro enterprises are rarely registered; hence quantification of their contribution to economy is difficult. Despite these limitations, micro enterprises tend to be more profitable entities because of the non-valuation of family labour and reduced overhead. Small enterprises are operated beyond the family boundary; however they are not regulated by any persisting industrial acts of Nepal. The examples for small enterprises are timber depot, furniture, NTFP collection and processing and bio-briquette production. Medium enterprises mainly include relatively high capital investment such as furniture industry, plywood and veneer industry, paper mills and wooden handcrafts.

It has been estimated that forestry and agriculture in Nepal provides direct employment to six and a half million of the labour force which is four-fifths of total economically active population (ANSAB, 2009). Four and a half million labourers are self employed, and over two million work as wage labourers. Almost half of the wage workers are part-time workers, coming from marginal and small holdings. Another one million labourers are full time farm wage workers (ANSAB, 2009). These workers are landless and subsist on wage income. Out of every 10 full time wage workers, 7 work as casual workers, and 3 work under a permanent labour relationship generally interlinked with credit and land relationships.

11. Process followed for preparing this Country Report

The following steps were undertaken during the preparation of the country report:

- The Ministry of Forests and Soil Conservation was identified as a focal point for contact between Nepal and FAO. An under-secretary from Ministry of Forests and Soil Conservation was assigned for this purpose (**Appendix A**).

- In order to oversee the preparation of FGR, the Ministry of Forests and Soil Conservation formed a National Committee, representing different departments of the ministry and civil society. Fedration of community forestry user group's chairperson represented the civil society. Additionally, by the Central Department of Botany, appointed a member representing an academic institution.

- Upon consulting the National Committee, to support the FGR preparation, particularly to compile data and information, a working group was formed representing four departments of the ministry.

- A consultant was appointed to support the writing process specifically to assemble collected information and arrange them in a systematic manner.

- In the beginning of the writing process a National Stakeholder consultation meeting was organized in order to collect the information related to forest genetic resources and to seek any issues which are very relevant in the context of FGR preparation and future planning Government organization, non-governmental organization, academic institutions and private sector participated in the meeting. The name of institutions participated and consulted is given in **Appendix A**. In addition, a notice was published in the National daily news paper to provide information and issues related to forest genetic resources.

- Several meetings of the working group members were organized to prepare a draft report.

- The draft report was then discussed among the national committee members and comments and suggestions received were incorporated and then the report was presented in second national stakeholder consultation meeting to discuss widely. In the meantime comments gathered from the experts on the FGR have been incorporated.

- The focal point submitted the report to National Committee and then finally to the MFSC for official endorsement and submission to the FAO.

Chapter 1

The Current State of Forest Genetic Resources

1.1 Introduction

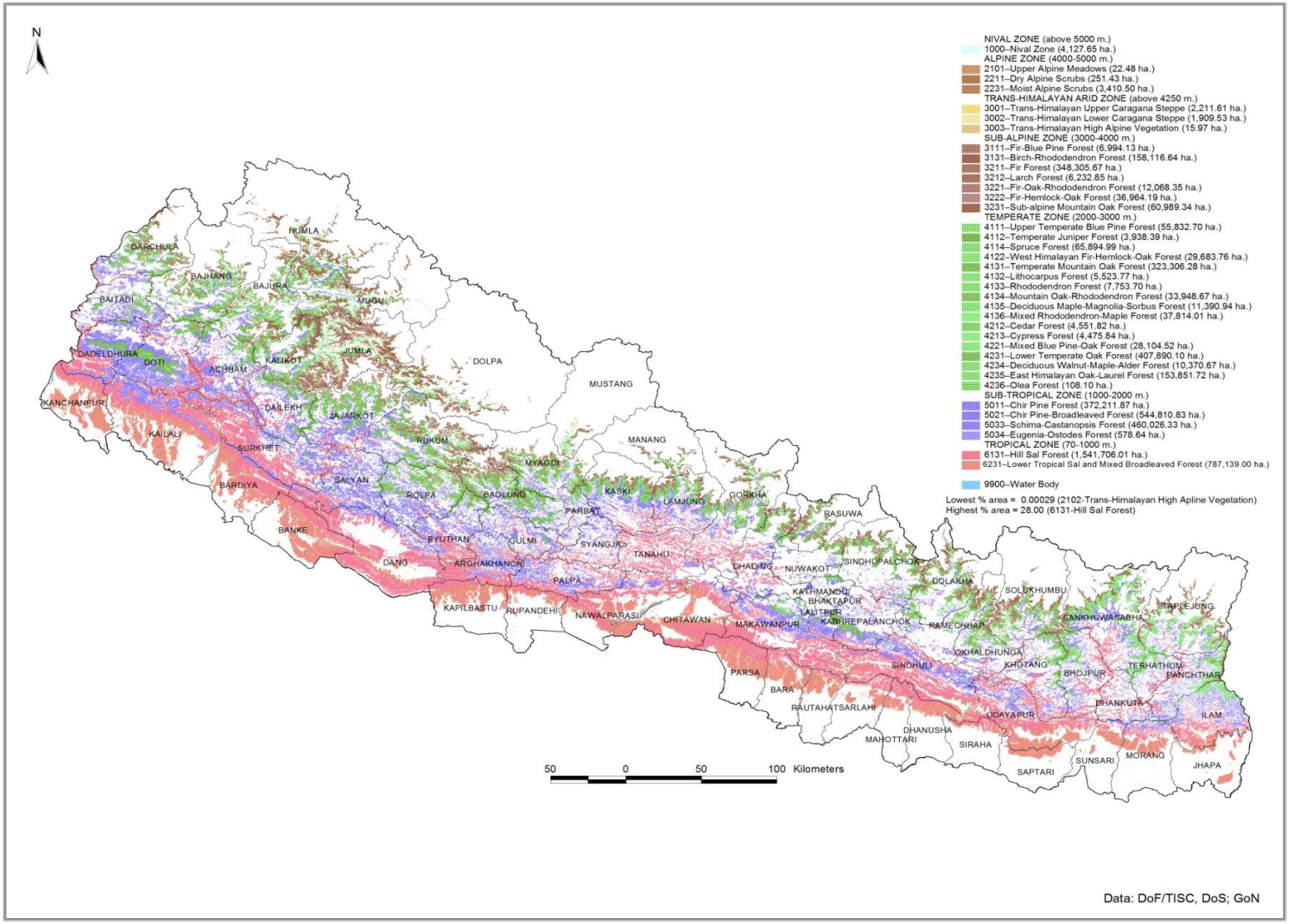
Wide altitudinal variations and diverse climatic conditions has made Nepal ecologically most diverse country in the world (NBS, 2002). The country is endowed with rich diversity, in terms of forest species (GoN, 2002). Nepal comprises only 0.09% of the global land area, but possesses 2.7% of the world's recorded flowering plants. A total of 5856 species of flowering plants, 28 species of gymnosperms, 853 species of bryophytes and 534 species of pteridophytes have been listed in the country (MFSC, 2009; Shrestha et al., 2010; Siwakoti, 2007).

Even though the country is rich in biological diversity, it is yet to be managed at its full potential. To realize its potential various program interventions at community, national and international level is desirable. Taking into account this fact, this Chapter explains current state of the forest genetic resources diversity in the country, more specifically diversity between and within the species. In addition, this Chapter explicates the values of forest genetic resources in terms of various uses. The state of current and emerging technologies, needs and priorities for improving the understanding of the state of forest genetic resources is also described in this Chapter.

1.2 The state of ecosystem and tree species diversity

As explained in Section II Nepal is divided into five ecological regions; named Tarai, Siwalik, Middle Mountain, High Mountain and High Himalaya. Given the extraordinarily large ecological variation in Nepal, great diversity is observed at ecosystem, species and genetic levels. Ecosystem classification is challenging in the context of Nepal owing to the biophysical diversity of the country. However, many researchers have attempted to classify the forest ecosystems and forest types in Nepal in different ways. Realising the fact that forest types and ecosystems are fundamental for planning and management; classification carried out by various researchers are simplified and reduced in number. Dobremez (1976) recognised 136 ecosystems and these were later reduced to 118 by ICIMOD/TISC in 1995, by grouping closely associated ecosystem types together**. Appendix B** shows the list of ecosystems as identified by ICIMOD/TISC. Likewise, Stainton (1972) recognised 35 forest types in Nepal which are widely recognised and used in forestry sector (TISC, 2002). List of forest types based on ICIMOD/TISC classification is given in **Appendix C**. The distribution of forest types across the country is as shown in the Figure 1.1.

Figure 1.1 Map of forest types in Nepal



The country is also rich in terms of tree diversity. Altogether about 400 tree species have been recorded (Howland & Howland, 1984; Jackson, 1994; Storrs & Storrs, 1998). A list of the tree species is given in the **Appendix D**.

Understanding of intra-specific diversity is an important prerequisite for the effective conservation of species (Falk & Holsinger, 1991). Low intra-specific genetic diversity can lead to inbreeding depression affecting growth, survival and adaptation (Kjaer et al., 2006). Few scientific studies have been carried out to find the genetic variation among the Nepalese forest tree species. Until the end of 2011, genetic variation of six species has been recorded (see Table 1.1). The species included are *Dalbergia sissoo, Pinus roxburghii, Shorea robusta, Taxus wallichiana, Alnus nepalensis, Rhododendron* spp. and *Cornus macrophylla.*

Studies on genetic variation for shrubs and herbs which are economically important have been recently drawing attention of many researchers (Dinesh Bhuju, 2011 personal communication). However, the general observation is that important genetic variation is most likely to exist between populations for the species that cover large and/or environmentally heterogeneous distribution areas. Many other parts of world have also shown that the ecological variation is closely associated with genetic variation in species (Lillesø et al., 2001).

Table 1.1 Forest tree species for which genetic variability has been evaluated

Species		**Morphological traits**	**Adaptive and production characters assessed**	**Molecular characterization**	**Researcher**
Scientific name	**N or E**				
Abies spectabilis	N			Yes	NAST (2011)*
Alnus nepalensis	N	-	Wood anatomical characters	-	Noshiro et al.,(1994)
Betula utilis				Yes	NAST (2011)*
Dalbergia sissoo	N	Straightness, branch angle, vigor	Disease resistance, site	**Yes**	Pandey et al., (2004)
Dalbergia sissoo	N	-	Mating system identity	-	Aryal (1996)
Pinus roxburghii	N	-	-	Yes	Gauli et al., (2009)
Pinus wallichiana	N			Yes	NAST (2011)*
Quercus semicarpifiolia	N			Yes	NAST (2011)*
Rhododendron spp.	N	-	Wood anatomical characters	-	Noshiro & Suzuki (1995), NAST (2011)*
Shorea robusta	N	-	-	Yes	Suoheimo et al. (1999), Pandey & Geburek (2010)
Taxus wallichiana	N	-	-	Yes	Bhattarai et al., (1998), NAST (2011)*

*Note; N=Native, E=Exotic. * Information based on personal communication*

The study has identified substantial intra-specific genetic variations within the *Dalbergia sissoo*, and can be illustrated with differences in colour of wood, height of tree and quality of wood. The

species found in the far western part of country is taller and possess good quality of wood as compared to the species from the other part of Nepal. The Sissoo isozyme and cpDNA study showed the higher level genetic diversity in natural sissoo stands compared to plantation (Pandey et al., 2004; Aryal, 1996). Similarly, the genetic diversity of the *Shorea robusta* was reported higher in Nepal (Pandey & Geburek, 2010). Pandey and Geburek (2010) further studied the genetic difference between continuous and disjunct Sal (*Shorea robusta*) populations in Nepal and found a higher level of genetic diversity in continuous as compared to disjunct populations. So far studies have been done, adopted methods based on molecular markers. Most of the molecular studies made upon Nepalese forest tree species have been done by Nepalese and foreign researchers in advanced laboratories in Europe and America. Among the methods employed to assess genetic diversity and distribution pattern, those based on molecular markers have been largely used for forest tree species.

1.3 Value of forest genetic resources

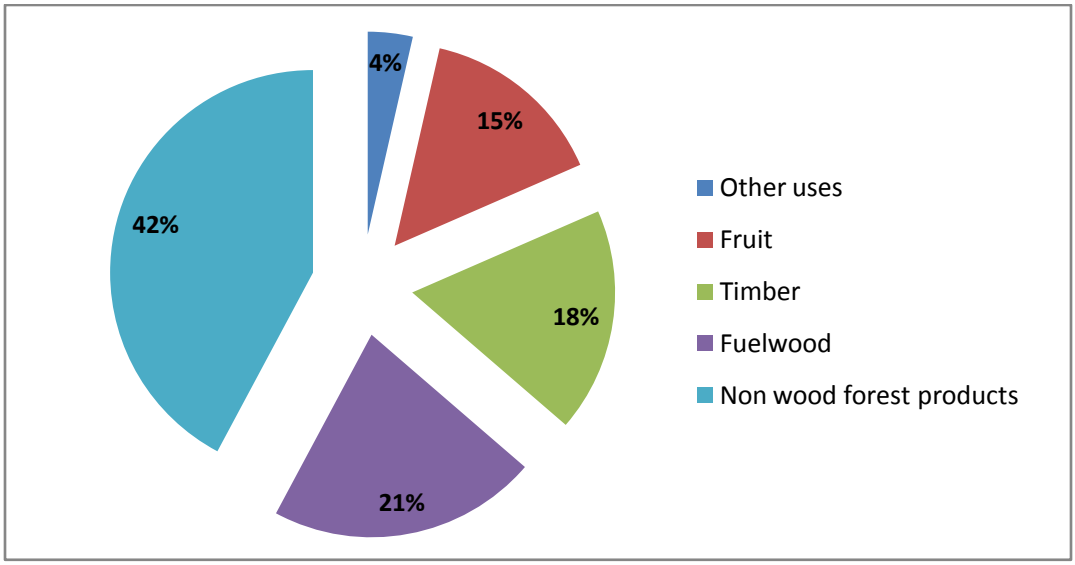
Genetic resources can be simply interpreted as the genetic diversity of the species, populations and the whole ecosystems. The amount and patterns of genetic diversity determine the adaptability of forest trees species (Müller-Starck et al., 1992) as species diversity does for the ecosystem. Rich level of genetic diversity provides opportunities to adapt the species, populations and the ecosystem in the context of changing climate. Therefore, long-term conservation of forest genetic diversity is fundamental for sustainable forest management, especially under climate change. Genetic diversity and healthy gene pools are essential elements for the stability of the ecosystem.

Several studies suggested about the significant effects of genetic diversity on primary productivity, population recovery from disturbance, interspecific competition and community structure (see review by Hughes et al., 2008). The substantial increase in productivity was reported in the plant population with comparatively higher genetic diversity (Bell, 1991; Crutsinger et al., 2006; Smithson & Lenne, 1996). Population genetic diversity in foundation species is crucial for the maintenance and sustainability of the species and ecosystems. Forest genetic resources can be crucial to increase agricultural productivity and ensure its sustainability. For example, the availability a large number (about 120) of the wild varieties of the commonly planted food plants at the proximity (GoN, 2002) indicates for the potentiality to launch the successful breeding programme to improve the productivity and the resistance against biotic and abiotic adversities. It may further provide opportunities to generate economic benefits by developing variety of the species of economic values.

The main stay of economy of the country is based on subsistence agriculture. Agriculture is linked to FGR and supplies many inputs to agriculture production. Besides, rural communities are highly dependent on forest products for their livelihoods hence the forests are managed for direct consumable forest products such as timber, fuel wood, fodder, litter and environmental

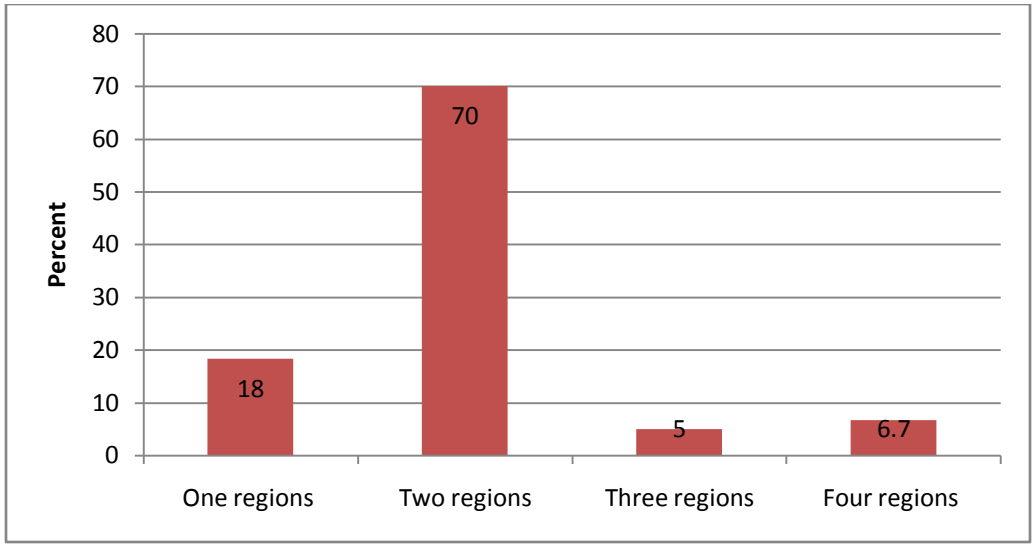
services. Many tree species in the country have potential for multiple uses. Among the tree species so far recorded are used for various purposes; most of the species are utilized for multiple purposes (see Figure 1.2) followed by fuel wood (21%). Only few species (4%) have been used for other purposes which include fruit, food and medicine.

Figure 1.2 Proportion of different tree species and their use



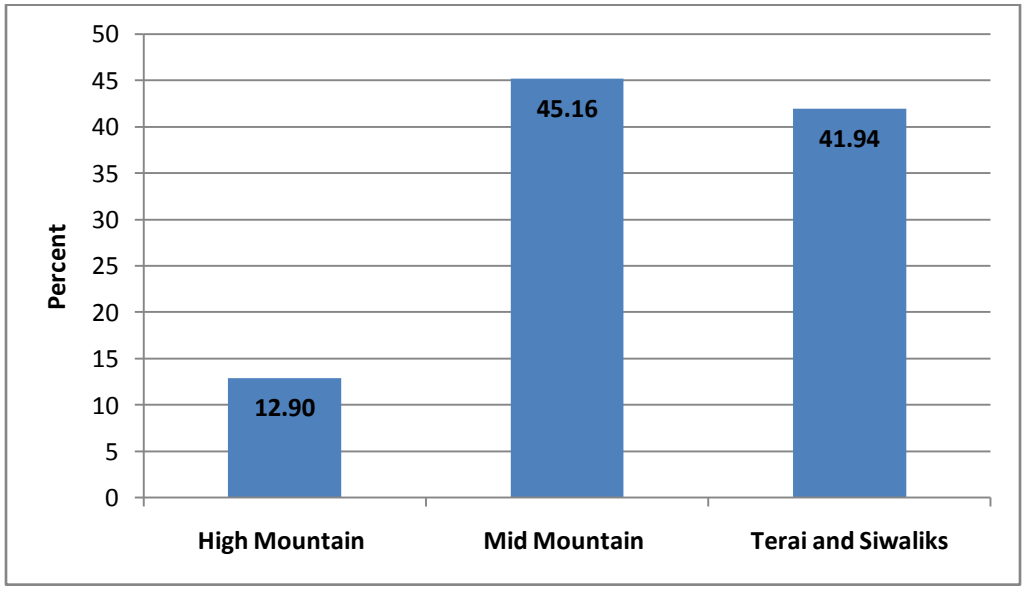
Besides the multiple uses, **Appendix E** shows the list of priority tree species which are largely used for economic reasons. Among the prioritized tree species large proportion of the species occurs in more than two physiographic regions. Figure 1.3 demonstrates the occurrence of priority species in different physiographic regions. Only 5 percent of the species do occur in the three regions. It is interesting to note that there are some species which have long range of distribution and occur in four regions. The species which occur all through Tarai to the High mountain region are *Ficus roxburghii*, *Ficus hispida* and *Ficus lacor*. The *Ficus* species are used for multiple purposes such as food, fodder, fuelwood and litter. High genetic diversity and wide distributional range of the tree species are very significant for adaptation of ecosystem to climate change. Ecosystems associated with these species are likely to have relatively more resilience capacity to mitigate climate change effect than other ecosystems.

Figure 1.3 Occurrence of priority species over different physiographic regions (%)



The distribution analysis of priority species across the physiographic regions shows that a large proportion of the species (45%) are found in the Mid Mountain followed by Tarai and Siwaliks (Figure 1.4). On the other hand, only 12 percent of the species occur in the High Mountain. The probable reason for higher number of species that have been used in the Middle Mountain is the diversity in the uses of forest products among the people of the regions.

Figure 1.4 Distribution of priority species along the physiographic zones

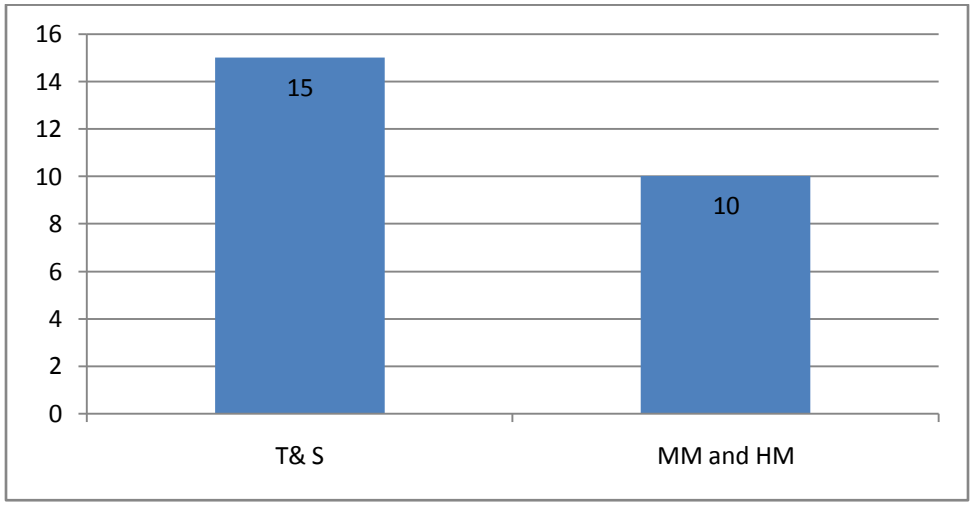


1.3.1 Species used for timber

Timber is the main product for which the forests are managed. However, demand for timber varies, depending on the socio economic condition of people.

There are many species which are used for timber production. List of the species used for timber is given in the **Appendix F.** The most commonly used tree species are *Shorea robusta, Pinus roxburghii, Terminalia alata, Dalbergia sissoo, Pinus wallichiana, Adina cardifolia, Albizia lebbek, Michelia champaca, Dalbergia latifolia, Toona ciliata,*. Only few exotic species are available for timber use. *Tectona grandis* is the main exotic species used for timber. It has been observed that greater numbers of species are available for timber use in Tarai and Siwaliks regions than the Middle Mountain and the High Mountain regions (see Figure 1.5).

Figure 1.5 Tree species available for timber use in different physiographic regions



T& S= Tarai & Siwaliks, MM= Middle Mountain, HM= High Mountain.

1.3.2 Non wood forest products from trees and forests

Other than timber, forest trees produce many other products such as fruit, food, fodder and medicine. Large numbers of species are used for non wood forest products (see **Appendix F**); the most widely used species includes *Ficus* spp., *Quercus* spp., *Pterocarpus marsupium, Bauhinia* spp., *Prunus cerasoides, Morus alba, Melia azedarch, Butea monosperma.*

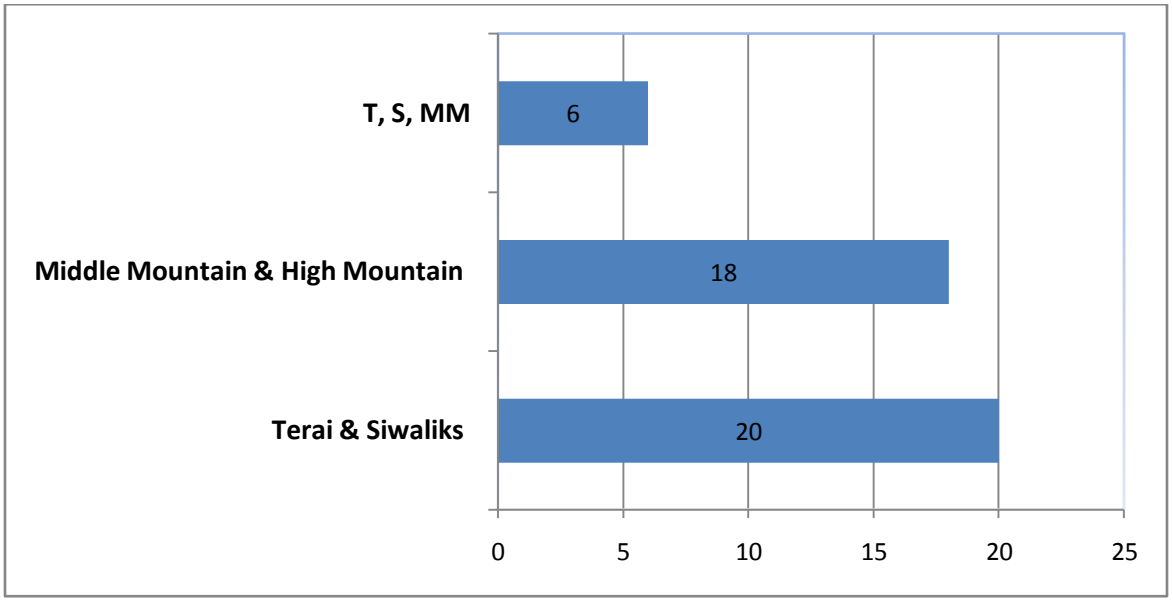
Trees for agroforestry systems

Both native and exotic species are used for agroforestry practices. The species are either deliberately planted or are managed within their natural habitat to improve agricultural productivity. Among the exotic species, the most widely used are *Populus deltoides, Eucalyptus camaldulensis, Acacia nilotica, Leucaena leucocephala,* and *Morus alba*. There are large numbers of native species which are used for agroforestry purposes, predominantly include

Dalbergia sissoo, *Prunus cerasoides*, *Melia azedarach*, *Ficus* spp., *Bauhinia* spp. and *Alnus nepalensis*. The list of the species used for agroforestry is given in **Appendix F**.

The distribution of agroforestry species across the physiographic regions indicates that larger numbers of species are available in both Tarai and Siwalik regions relative to the Middle Mountain and the High Mountain regions (see Figure 1.6). There are only few species (six species) which are found in all three regions; Tarai, Siwaliks and Middle Mountain and have potential for agroforestry.

Figure 1.6 Distribution of agro-forestry tree species across the physiographic regions



T: Tarai, S: Siwaliks, MM: Middle Mountain

Basically all tree species could be used for fuelwood; however there is a group of species that is generally preferred. The species are preferred which usually burns without excessive smoke and unpleasant odor. The preference of species varies from place to place due to availability of the preferred species in sufficient quantities (**Appendix F**). Among the native species, the most commonly used tree species in the different regions are identified as *Aesandra butyracea, Alnus nepalensis, Betula alnoides, Cassia fistula, Diospyrus melanoxylon, Engelhardtia spicata, Fraxinus floribunda* and *Lyonia ovalifolia.*

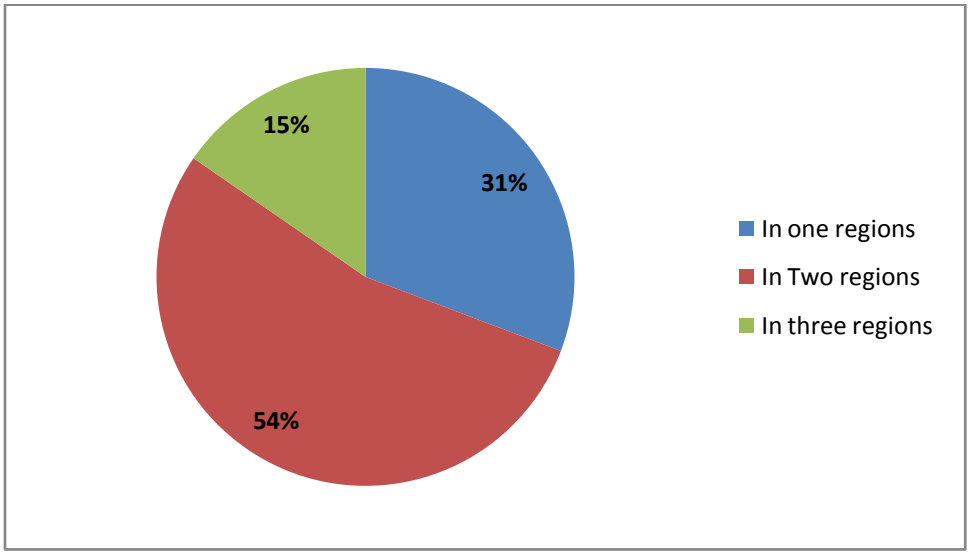
Besides timber, fodder and fuel wood, many species are used for other uses that includes pulp and paper, extractives and fruit in times of food shortage. However, there number is very small. *Daphne bholua* is the main species used for paper making. Other important species used are *Eucalyptus* species for fibre, *Acacia catechu*, *Acacia nilotica*, *Azadirachta indica, Aesandra butyracea* and *Cinnamomum camphora* for extract, *Bombax ceiba* for plywood (Sah & Dutta, 1998). Species such as *Aegle marmelos, Artocarpus lakoocha, Bauhinia variegata,*

Choerospondias axillaris, Ficus semicordata, Phyllanthus emblica, Antidesma diandrum, Tamarindus indica, Randia dumetorum provides fruits which can be used in times of food shortage (Shrestha & Dhillion, 2006; Uprety et al., 2010).

1.3.3 Environmental services

The main environmental services include provisioning, supporting, regulating and cultural (Fisher & Kerry Turner, 2008; Wallace, 2007). Although, practically all tree species provides some sort of environmental services, there is a group of species that is generally preferred. Based on studies in Nepal there are about 70 tree species that are currently used for indirect use (Acharya, 2003). The specific uses of the species are as given in **Appendix G**. Many species are being used for more than one purpose. Tree species such as *Acacia catechu, Alnus nepalensis, Albizia procera* are used for more than two purposes. It is observed that most of the species used for indirect uses are native. Only few species such as *Acacia arabica, Casuarina equisetifolia, and Leucaena leucocephala* are exotic species which are used for indirect use. *Bambusa balcooa, Ficus* species *and Bauhinia* species are some of the most widespread and useful trees in providing environmental services. The distribution of forest tree species across the physiographic region shows that majority of the species (54%) are found in more than two regions, 13 % of the trees are found in more than three regions (see Figure 1.7).

Figure 1.7 Distribution of tree species used for environmental services across physiographic regions



1.3.4 Threatened Species

A systematic survey on the evaluation of the threatened species has not been carried out. A general observation and some studies have identified that some species are considered as threatened. For example, *Dalbergia latifolia* which is very valuable timber species has already

disappeared from the Tarai and now occur scattered in foot hills of Siwalik. Likewise *Pterocarpus marsupium,* is also threatened because of its multiple uses such as medicinal and timber. A large number of other species are also added to the list. Table 1.2 shows list of threatened forest tree species and their physiographic distribution. Other than species which are found in the forest, many species are threatened which are only found in the agriculture farms.

Both *ex-situ* and *in-situ* conservation initiatives are being implemented to ensure the conservation of threatened species. Tree improvement program of DoF and DFRS have initiated conservation of threatened species such as *Dalbergia latifolia, Pterocarpus marsupium, Aesandra butyracea, Dalbergia sissoo, Phyllanthus emblica* by establishing different experimental plots, *in situ* conservation area, and BSOs (Breeding Seedling Orchards). To this end, seed stand and breeding seedling orchards have been established in their respective planting zones. In addition, Botanical Gardens have been set up in different physiographic regions to conserve the threatened species. Legal interventions are also in place to prevent the further deterioration of the threatened species. Forest Act, 1993 bans on green felling of *Acacia catechu, Michelia champaca, Juglans regia, Myrica esculenta, Bombax ceiba, Shorea robusta* etc. from the farm land. However, threatened species such as *Populus ciliata* are yet to recive conservation intervention. For better conservation of threatened species, a long term commitment, financial resources, trained human resources are essential. So far not any comprehensive study has been carried out to assess the status of forest tree species. Thus, comprehensive study and the regular evaluation of status of the species is other crucial strategy for conserving threatened species.

Table 1.2 Threatened tree species in Nepal

SN	Species	Physiographic zone	SN	Species	Physiographic region
1	*Abies pindrow*	HM	26	*Gmelina arborea*	T
2	*Picea smithiana*	HH	27	*Helicia nilagirica*	T
3	*Abies spectabilis*	HM	28	*Juglans regia*	MM
4	*Acacia catechu*	T	29	*Larix griffithiana*	HM
5	*Aegle marmelos*	T	30	*Larix himalaica*	HM
6	*Alstonia scholaris*	T	31	*Lithocarpus fenestrata*	MM
7	*Aesandra butyracea*	MM	32	*Magnolia globosa*	HM
8	*Bauhinia variegate*	T	33	*Michelia champaca*	MM
9	*Boehmeria rugulosa*	S	34	*Michelia kisopa*	MM
10	*Bombax ceiba*	T	35	*Myrica esculenta*	S
11	*Bridelia retusa*	T	36	*Olea ferruginea*	S
12	*Butea monosperma*	T	37	*Oroxylum indicum*	S
13	*Betula utilis*	HM	38	*Pistacia chinensis*	MM
14	*Calamus acanthospathus*	T	39	*Podocarpus neriifolius*	T

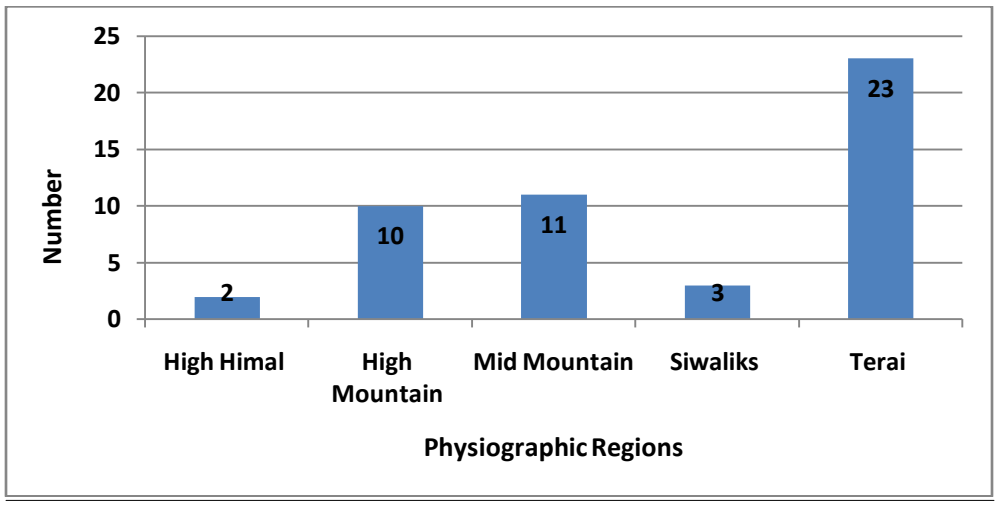
15	*Cedrela toona*	T	40	*Premna latifolia*	T,S
16	*Choerospondias axillaris*	MM	41	*Prunus carmesina*	MM
17	*Crateva unilocularis*	T	42	*Pterocarpus marsupium*	T
18	*Cycas pectinata*	T	43	*Rhododendron arboreum*	HM
19	*Dalbergia latifoloia*	T	44	*Syzygium cumini*	T
20	*Dalbergia sissoo*	T	45	*Talauma hodgsonii*	MM
21	*Elaecarpus sphaericus*	T	46	*Taxus wallichiana*	HM
22	*Phyllanthus emblica*	T	47	*Tetracentron sinense*	HM
23	*Engelhartia stricata*	T	48	*Ulmus wallichiana*	HM
24	*Erythrina arborescens*	S, MM	49	*Vitex negundo*	
25	*Ficus benjamina*	T			

Sources: IUCN Red list, Siwakoti (2007), Shrestha & Joshi (1996)

Species such as *Dalbergia latifolia*, *Pterocarpus marsupium* and *Michelia champaca* are threatened at the species level. The threat of extinction is high for these species because of their restricted geographical and ecological range and over exploitation. *Pterocarpus marsupium* is largely found in the western and far western Tarai region of the country. Likewise *Dalbergia latifolia* is found in the central part of country primarily in the Tarai. Both of these species are extensively harvested for multiple uses and high economic value.

The distribution of threatened species across different physiographic regions demonstrates that large number threatened species are from the Tarai and Middle Mountain regions and only small numbers of species are from High Himal and Siwaliks. Possible reason is increased utilization of forest species resulting from high population density in the Tarai and the Middle Mountain.

Figure 1.8 Distribution of threatened tree species over different physiographic regions



1.3.5 Endemic forest tree and other woody species

Endemic plants are those which occur naturally in one place and nowhere else. Although Nepal is endowed with a large number of endemic plant species, only few tree species are recorded as endemic to the country. Researchers have reported that 286 plant species out of 5,100 species are endemic to Nepal (Rajbhandari & Dhungana, 2010; Rajbhandari & Dhungana, 2011; Rajbhandari & Adhikari, 2009). Among total 286 endemic plants only 14 tree and bamboo species are endemic to Nepal. Table 1.3 elucidates the horizontal and vertical distribution of endemic tree and bamboo species in Nepal. It was found that maximum numbers of endemic plants occur in central region of the country and similar trend was observed in the tree species case (Table 1.3).

An analysis of pattern of endemic species richness in the country shows that proportion of endemic species increases steadily from low to high elevation (Vetaas & Grytnes, 2002). Vetaas & Grytnes (2002) have reported that high endemic species of vascular plant species have been occurring at high elevation. The highest endemism diversity is observed at the start of a rapid decrease in species richness above 4000 m (from mean sea level) which is corresponding to elevation beyond which plant species diversity declines sharply. This is because of the isolation mechanism, where glacier and sharp altitudinal gradient enhances the probability of isolation (Vetaas & Grytnes, 2002). Diversity of endemic species along with biogeographical variation is important for conservation of biological diversity.

Table 1.3 Endemic bamboo and tree species of Nepal

SN	Species	Altitude (m)	Regions	Physiographic region
1	*Borinda chigar*	3,000	W, C	HM
2	*Borinda emeryi*	3,000	C	S, MM
3	*Brommus nepalesis*	3,000	W	S, MM, HM
4	*Himalayacalamus asper*	2,000	C	HM
5	*Himalayacalamus cupreus*	2,500	C	HM
6	*Himalayacalamus fimbriatus*	1,200	W, C	MM
7	*Himalayacalamus porcatus*	2,270	C	MM
8	*Persea tomentosa*		C	
9	*Persea blumei*	1,350		
10	*Prunus himalaica*	3,900	C	HM
11	*Prunus jajarkotensis*	900-1000	W	MM
12	*Sorbus sharmae*	3,170		
13	*Salix nepalensis*	3,870		
14	*Wendlandia appendiculate*	1,400	C	MM

Note: C= Central, E=Eastern, W= Western, HM= High Mountain, MM=Middle Mountain, S=Siwaliks
Sources: Rajbhandari & Adhikari (2009); Rajbhandari & Dhungana (2010); Rajbhandari & Dhungana, (2011).

1.3.6 Threats to conservation of genetic resources

Various evolutionary factors have been interacting with each other in nature to shape the forest genetic resources. Gene flow via seeds, pollens and reproductive materials, mutation event, population size of the species and inbreeding events have strong impact upon genetic resources of the species and population (Eriksson et al., 2006; Finkeldey & Hattemer, 2007). Human interferences in the nature in the form of management or mismanagement, excessive exploitation, fragmentation, transfer of genetic materials may have change one or many of these factors ultimately threating the forest genetic resources.

Deforestation and forest degradation are considered main threats to the forest tree species in Nepal. Conversion of species rich forests to plantations (eg. Sagarnath, Ratuwa Mai and Nepalgunj forest development projects), expansion of area for agriculture production, establishment of new settlement, and various types of development activities are major causes of deforestation and threats for the FGR loss. The figures related to change in forest indicated that the forest area has decreased at an annual rate of 1.7%, whereas forest and shrub together decreased at an annual rate of 0.5% during the period of 1978/79 to 1994. Recent studies in 20 Tarai districts revealed that forest cover decreased at an annual rate of 0.06% from the period of 1990/91 to 2000/2001 (DoF, 2005).

Second reason is the over exploitation of selected tree species. Loss of genetic diversity is more prevalent in the species which are economically important. The phenotypic selection of the superior trees for harvesting may have also the selection of the most adapted trees. The irreversible loss of the superior tree might the irreversible loss of the superior genotypic traits. Economically important species are under over exploitation consequently resulting bottleneck and genetic drift for example the exploitation of *Dalbergia latifolia, Michelia champaca* and *Pterocarpus marsupium* in Nepal. *D. latifolia* and *M. champaca* are highly valuable species for timber, particularly for furniture making. *Pterocarpus marsupium* is valued for its pharmaceutical properties such as being an astringent used for the treatment of dysentery, diarrhoea, fever and toothache (Gupta & Gupta, 2010).

Absence of sustainable management practices is also an important reason behind the loss of genetic diversity. Rural communities in Nepal are highly dependent on the forest resources for their livelihoods. About 85% of the energy requirement is fulfilled from the fuel wood from forest (Nepal Forestry Outlook Study, 2009). Over 40% of fodder needs are met by forests (Acharya, 2006). This high dependency sometime leads to harvesting of fuelwood and fodder more than sustainable yield of a forest resulting harvesting of the species which are already threatened (GoN, 2002). Degradation of forest may escalate further along with ever growing population and their demand for fuelwood, timber and leaf litter and other forest products.

Another reason is the inappropriate application of silvicultural techniques. Selective felling is commonly adopted silviculture technique in Nepal (Acharya et al., 2007). In selective felling, trees with desired characteristics are removed as a result trees with undesired characteristic are

left to grow. These undesired characteristics might be controlled due to their poorer genetic make up, further deteriorating their genetic traits in next generation. In addition, the present forest management strategy is directed towards the production of wood products. For wood production only tall trees with straight stem are generally selected. Hence the silvicultural techniques which favour only few characteristics may reduce the tree genetic variability (Jennings et al., 2001).

Fragmentation of forest land is one of the key factors causing the loss of genetic diversity. Execution of many development activities inside the forest land has been causing fragmentation. Fragmentation of forest land is very common in the Middle Mountain (Gautam et al., 2003) and Tarai regions due to the expansion of settlement and infrastructure development. Over harvesting, shifting cultivation, frequent forest fires, over grazing etc have also induced the fragmentation of the forests. Fragmentation increases inbreeding and genetic drift and reduces gene flow between populations (Honnay et al., 2005). Hence, fragmentation is not only reducing the area of forest, but also deteriorating the genetic variability among the tree species.

Genetic consideration related to the plantation generally emphasised on the use of locally adopted genetic material. However, the level of genetic diversity in the planting material is important as well. In Nepal, often use of unauthorized seed sources with narrow gene base for planting materials has been reducing forest genetic diversity. Seeds are generally collected from tree species which are locally available for reducing cost of collection (Gauli et al., 2009). The genetic base may still be narrow for the farm land seed sources. Many tree species in Nepal have often been planted from seeds, cuttings and wildings from an unknown and small number of mother trees (Dhakal et al., 2005). These practices have been leading to the loss of genetic diversity consequently degenerating the quality of forest genetic resources.

1.3.7 Forest tree species priority setting exercises

Government takes consideration of various factors while prioritizing the species though there is no any formal guidelines and method in practice. In Nepal, the initial selection of species for domestication was based on the two tools, 'asking scientists', and 'asking farmers' (Kjaer et al., 2006). Species are prioritized for conservation which are listed as threatened by various agencies such as IUCN. Besides, conservation activities are implemented for those species which are thought to be threatened by general public and farmers. Government agencies collect status of species through research studies carried out in various regions of county. In this regards, TISC and Department of Forest Research and Survey (DFRS) are involved. TISC has prioritized species for different uses based on the local preferences of farmers associated with forestry. Local farmers through experience retain knowledge regarding tree crop interaction and about nutrition contents of the local fodder species. In addition, TISC has developed criteria based on the planting zone. First priority is based on the planting zone system that is species are chosen in the site where it is able to survive and grow. Second priority is the usefulness of species for particular purpose. Vegetation maps prepared by TISC are used to identify the potential species for particular physiographic region.

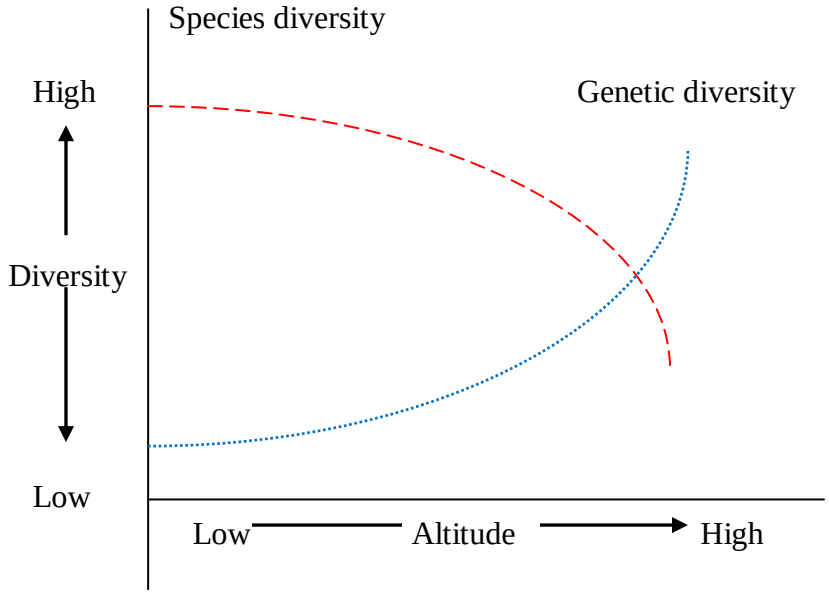
To some extent, studies by Upadhaya (1992), Panday & Nösberger (1985), Amatya (1990), Kayastha (1998) have provided local preferences of fodder species, however they do not provide growth potential of preferred species within the district and development regions. Likewise some studies (Carter, 1992; Chapa, 1994; Rusten & Gold, 1991) have provided preferences for fodder species based on the altitudinal variation along with detail understanding of variation of species availability and possibility of growth (Thorne et al., 1999).

1.3.8 The state of genetic diversity for main species

No systematic study has been carried out to assess the trend in genetic variability of most preferred species. However, the genetic diversity of the few forest tree species was studied by using isozymes and microsatellite markers (Suoheimo et al., 1999; Pandey et al., 2004, Gauli et al. 2009, Pandey and Geburek, 2009; Pandey and Geburek, 2010). Almost all the studies reported a high level of genetic diversity in Shorea robusta, Dalbergia sissoo and Pinus roxburghii. A general trend shows that species and genetic diversity vary along with altitude. While tree species diversity decreases with altitude, genetic diversity increases (see Figure 1.9).

The tropical region which mainly includes Tarai and Siwalik is endowed with high species diversity. Anthropogenic activities are high in the regions. However, both genetic and species diversity are more vulnerable due to anthropogenic pressure in the tropical region. The subtropical and temperate regions are blessed with relatively low species but high genetic diversity. These regions are relatively less disturbed by human pressure; hence diversity is relatively maintained in these regions. Some scattered studies such as by Gautam & Devoe (2006) has anticipated that over exploitation of species and fragmentation of the habitat may have declined the genetic variability of *Shorea robusta*. Gauli et al. (2009), Pandey et al. (2004) have found no sign of reduced genetic variation among the *Pinus roxburghii* and *Dalbergia sissoo* plantation respectively.

Figure 1.9 Relationship between altitude and species and genetic diversity



Source: Adopted from (ICIMOD, 2011)

1.4 The main factors influencing the state of forest genetic diversity

1.4.1 Relative change in species preference for their use

Preference over the tree species has changed over a decade. According to a report from TISC, before 1982 the chosen species were primarily the traditional timber species. This is because plantations were largely used to be established from the Department of Forests (DoF) (TISC, 2001). However, along with change in plantation establishment from DoF to community groups, leasehold groups and private growers, preference is now more towards the plantation of fodder and other multipurpose tree species. In addition, new livelihood priorities and opportunities have encouraged people to change their preferences to multi-purpose tree species. Even the same species which was managed earlier for timber has now been managed for multiple purposes.

1.4.2 Information systems on threatened species and trends in threats

There is no such monitoring mechanism to oversee trend of threat at the species level, nevertheless regular National Forest Inventory (NFI) which is carried out at the 10 years intervals provide information on the status of forest types and its associated species. The NFI is one of the several inventories used to provide forest information. NFI does not provide detail information on species distribution. However, stem record in the plot inventory while carrying out NFI give some indication of the general abundance in the country. Besides academic research carried out by students associated with different universities provides status of forest species (Acharya, 2006; Siwakoti, 2007). The researches are however, case and site specific therefore unable to provide comprehensive information.

1.4.3 Scientific and technical approaches used for monitoring genetic erosion and vulnerability

Genetic erosion is the reduction of within-population diversity – can directly affect the adaptive potential of our forests and should be avoided. There is not *per se* regular national program to assess the genetic erosion of the forest genetic resources. However, indirect assessments using some proxies have indicated likelihood of genetic erosion. The current rate of deforestation and extensive use of forest resource possibly indicate genetic erosion of forest species (Maxted & Guarino, 2004). Besides, research reports applying lab analysis, people's perception and experts' knowledge occasionally indicated loss of forest genetic resources in Nepal (Acharya, 2006; Chaudhary, 2000; Gauli et al., 2009; Pandey et al., 2004). Knowledge and experiences of local people are also potentially rich sources of information on loss of genetic diversity and this method is also widely accepted (Maxted & Guarino, 2004).

1.4.4 Scientific and technical approaches for preventing loss of FGR

Even in absence of systematic study of the species, based on the information available from the case studies, people's and expert's knowledge some scientific and technical measures are in place to avert the loss of FGR. The prominent measures include;

- *In situ* conservation
    - Established protected area network representing ecosystem types and maintain connectivity in landscape
    - Established seed stands
- *Ex situ* conservation
    - Established botanical gardens
    - Established BSOs
    - Adopted tissue culture technology
    - Germaplasm conservation

Many studies have indicated that some species which are assumed to be threatened are occurring in farm land (Acharya, 2006). Hence, incentive measures could be implemented to provide incentive to farmers for conserving those genetic resources. It is widely conceded that in order to ensure the conservation, government has to prepare national conservation plan for the species which are thought to be threatened. Unless the clear information on the status of genetic resources is available, approaches implemented on ad hoc basis is less likely to be successful in preventing the loss of genetic resources.

1.4.5 Policy tools and instruments employed to address the loss of FGR and vulnerability

Policy tools and instruments are essential along with preventive measures to address the degradation of FGR and their vulnerability. To this end, the government has prepared the National Biodiversity Strategy (NBS), 2002 which highlights an overview of Nepal's

biodiversity along with major achievements, gaps and future strategies. NBS emphasized on inventory of species in protected areas and throughout the country. A species conservation plan that focuses on the keystone species is a serious concern of the NBS. The strategy insists high priority to the conservation of ecosystem with high level of species diversity, endemism, and threatened plant species. Following NBS, numerous policies such as wetland, rangeland has been developed and implemented accordingly. Forest Act 1993 and Forest Regulation 1995 have provision to protect species which are likely to be threatened. Other than national policies, government is adhering international treaties such as CITES.

Although policies are in place to conserve rich biodiversity and forest genetic resources of the country, unexpected loss of genetic resources from various natural and anthropogenic reasons cannot be ruled out. To mitigate such situation, Nepal has implemented landscape-level conservation initiatives connecting different ecological regions through the maintenance of the effective corridors for genetic exchange. However, these approaches are not sufficient to combat biodiversity and FGR loss.

1.4.6 Constraints and reconciliation mechanisms to replenish the FGR loss

There are many constraints to establish effective forest genetic resources disaster responses mechanism. First, there is no information system. Comprehensive information regarding the level of genetic loss is lacking, and the available information are scattered and sketchy. There is no such policy to response to forest genetic resources. Other obstacle includes inadequate trained staff deputed in genetic resources. There are only few staff having knowledge about the genetic studies under Ministry of Forest and Soil Conservation. Hence, it is essential to enhance capacity of the staff.

No incidence of disaster causing genetic loss has been recorded in Nepal except the one in which disease and pest infested large area of *Dalbergia sissoo*. This species is a popular among private tree grower and government agencies due to it fast growth and multiple use properties. The disease results the die-back in the species. Planting trees on forest and private lands is a long tradition in the country. To stop further disaster, government had formed an expert's study team to identify the cause of disease and to recommend the plan of actions to mitigate the disaster and necessary prescriptions for future. To this end, alternative species has been used replacing *D. sissoo*. Pandey et al., (2004) did the genetic study of the plantation and natural stands of *D. sissoo* from southern parts of the country and reported that the genetic make up of those natural and plantations stands are distinctly different, indicating the long distance, most probably India as the seed source of the plantations. These plantations have been heavily infested with die-back disease and wilting whereas the natural stands are not facing any disease. Government has been emphasising more on conservation of natural population of *D. sissoo* instead of its plantation. In addition, priority has been given to identify seed sources which are disease resistant through tree improvement programme.

1.4.7 Needs and priorities to improve FGR disaster response mechanisms

- Improve forest resources disaster response following needs and priorities are essential;Promote participatory approach of FGR management
- Control deforestation and fragmentation of the forests
- Increase population size of most threatened species
- FGR information management system and clearing house mechanism
- Human resources development
- Create awareness to the local communities about FGR
- Establish forest gene bank
- Promote genetic studies of commercially important tree species
- Develop early warning system for genetic loss
- Establish functional network between national and international research institutes and universities

The following activities are required to improve the regional and international disaster response mechanism;

- Collaboration and linkages at local, regional and global level
- Capacity building
- Sharing of information at the international level

Priorities to improve monitoring of genetic loss and vulnerability and improve the response to observed loss of genetic resources include;

- Development of early warning system for the loss of genetic diversity
- Creation of awareness to the local communities
- Human resources development.

1.5 Future needs and priorities

1.5.1 Capacity-building needs to enhance for assessments of the state of diversity of FGR

Loss of genetic diversity is the common threat to the sustainable use of forest genetic resources to meet the present needs and aspiration of future generation. Loss of important genetic resources is noticeable in the country. To enhance the assessment of the state of diversity of forest genetic resources, including ways to better assess genetic information and understanding of the causes of loss of genetic diversity, following capacity building needs to be taken:

- Institutionalization of FGR conservation and management system in the country.
- Establishment of genetic labs, and promote academic degree program on 'Forest Genetics'
- Capacity development in operation of genetic laboratory and data analysis (population genetics, conservation genetics, molecular genetics) as well as taxon identification, ethno-botany, etc.
- National, regional and global collaborative projects to promote bioprospecting.

1.5.2 Priorities for improving understanding of the state of diversity of FGR

- FGR documentation.
- Assessment of genetic diversity loss within and between population and state of vulnerability.
- Human resource development.
- Scientific database management.
- Establishment communication network.
- Network with national and international research institutes and universities.
- Integration of FGR conservation and management in national planning.

1.5.3 Priorities to better understand the roles and values of the diversity of forest genetic resources

It is essential to understand the roles and values of diversity of forest genetic resources in terms of economic, social, cultural and ecological value. Knowledge of ecological services and diverse value of forest diversity would enhance the conservation and sustainable use of diversity. It is generally challenging however, essential to estimate economic value of forest genetic resources. Unless economic value of forest genetic resources is realized by local community, its conservation is unlikely.

1.5.4 Strategic direction to improving understanding of the state of FGR diversity

- Priority to the research related to FGR and disseminates of the information widely.
- Establish a monitoring mechanism.
- Carry out FGR inventory for the species which are economically and ecologically important.
- Many institutions such as The Mountain Institute, Biodiversity Profile Projects and Central Department of Botany, Tribhuwan University attempted to establish database for forest genetic resources, however coordination among these organization is weak (Chaudhary, 2000). Hence, instead of establishing separate database by each organization, a unified single database system would be more effective.
- Establish linkages with academic and non-academic institutions which are involved in FGR conservation and study.
- Promoting community based FGR diversity conservation and management.
- Networking of decentralized seed production and distribution.

1.5.5 The level of perception of the importance of forest genetic resources

Knowledge of communities' perception is important to enable implemented government policy and program achieved desired goal. Level of perception regarding the importance of forest genetic resources is not same among the government staff and general public (Acharya, 2006). To some extent, by training and education government staff received knowledge of importance of genetic diversity. In the case of general public, it is observed that farmers have been capturing

the benefits of genetic diversity through their traditional practices, which are based on their local skills and knowledge. The practices appear to have good convergence with benefits of genetic diversity as stipulated theoretically.

Needs and priorities for improving understanding of the state of forest resource genetic diversity and conservation and management

- A detail study on the forest genetic resources is needed.
- Assess the conservation status of the target species and their populations.
- National management plan for the species which appears as a threatened and keystone species.
- A monitoring mechanism is also needed.
- Mechanism to disseminate the importance of genetic diversity to grass root level.

Priorities to better understand the roles and values of forest genetic resources

- Make a policy to internalize the value of forest genetic resources.
- Carry out studies to indentify economic, social and cultural values of genetic resources.
- Enhance efforts to establish linkage between forest genetic conservation and climate change.
- Government has successfully handed over more than 17000 of forest patches to the community for protection, management and utilization (DoF, 2011). Therefore, it is essential to realize the benefits of forest genetic resource to the community for sustainable use of genetic resources.

The level of the intervention required

- Forging partnerships with international community generating benefits from genetic resource conservation.
- Human resource development.
- Organizational capacity development.
- Identify and fully exploit the potentials of genetic resources for climate change adaptation and mitigation.

Chapter 2

The State of *in situ* Genetic Conservation

2.1 Introduction

In situ conservation emphasizes the conservation of genetic diversity of populations at their natural sites of origin. Problems such as over-exploitation of resources, deforestation, climate change and desertification have been affecting the genetic diversity of forest resources. Besides, demand for forest products is ever increasing and this demand is putting pressure on forest resources. Therefore, by conserving genetic diversity where it occurs naturally, we can facilitate the natural process of evaluation and adaptation, thus mitigating the effect of these problems.

Government has been initiating *in situ* conservation for many decades. However, *in situ* conservation initiative has not covered all forest ecosystems. Various agencies undertake *in situ* conservation and share responsibilities among them. Coordination in planning and implementation among the agencies appear weak and insufficient. This chapter highlights the current state of *in situ* conservation of forest genetic resources and needs and priorities for its improvement. In addition, this Chapter explains the national, regional and global intervention required to improve *in situ* conservation programme of the country.

2.2 Categories of *in situ* conservation areas

A great deal of efforts has been made to conserve forest genetic resources in their native environment. Broadly, Nepal is implementing *in situ* conservation within and outside the protected area (PA) systems. Various types of protected areas have been established to implement *in situ* conservation. Besides, *in situ* conservation has been adopting various forest management regimes. These include community forests, government managed forests, protection forests, religious forests, and leasehold forests. Within these management regimes, the government implements various *in situ* conservation programmes. The most prominent programmes are establishment of seed stand and gene conservation areas for threatened and economically important species. Various institutions have been engaged in *in situ* conservation of the FGR of the country.

2.3 Institutions involved on *In situ* conservation

The Ministry of Forests and Soil Conservation (MFSC) is a specialized governing institution for *in situ* conservation of FGR. Its departments are primarily responsible for *in situ* conservation. The key institutions involved are DoF, Department of National Parks and Wildlife Conservation (DNPWC), Department of Plant Resources (DPR) and Department of Forest Survey and Research (DFRS). DNPWC is responsible for the management of PA network of the country and

National Park and Wildlife Conservation Act 1973 (and its amendments) guides the functioning of the department. DoF has mandate for management of forests outside the PAs. Forest Act, 1993 and Forest Regulation, 1995 guide the functioning of DoF. The DPR is the other agency that is responsible for the research and development of plant resources in Nepal. The department is mainly concerned with maintenance of botanical gardens, chemical and biological researches for the utilization of medicinal, aromatic and other valuable plants. Also, the department carries out biotechnology research, improvement and propagation of plants of economic value. DFRS is mainly responsible for performing all kinds of forest related research. This organization also undertakes National Forest Inventory to evaluate the status of the forest resources in the country at regular intervals.

Apprently all departments are more or less involved in *in situ* conservation of forest genetic resources. DoF involves in *in situ* conservation by establishing seed stands and gene conservation area. TISC under DoF involves in establishing seed stands. TISC mainly targets species which are economically important, rare and endangered. DFRS is mainly engaged in improving the genetic resources of tree species through improved management practices including *in situ* conservation. Although various institutions are involved in *in situ* conservation related activities, there is lack of coordination and systematic national priorities setting for *in situ* conservation. It appears that each department works within their own mandates, need and priorities. Duplication of the works has been noted in many instances. Sharing of knowledge amongst the departments is also not adequate. In addition, the departments are in short of funding, trained human resources, skills and knowledge. The *in situ* conservation of forest genetic resources has not received adequate national priority.

2.4 Conservation of forest genetic resources within PAs

Establishment and management of national parks and wildlife reserves in different physiographical regions are helping in *in situ* conservation. The concept to develop PAs in Nepal was largely started to protect the wildlife, especially endangered species. PAs do not alone include all the important forest genetic resources. The National Park and Wildlife Conservation Act-1973 identifies six categories of PAs namely national parks, wildlife reserves, strict nature reserves, hunting reserves, conservation area and buffer zones. Of the total PAs, ten are national parks, three are wildlife reserves, one is hunting reserve and six are conservation areas covering an area of 33,648 square kilometres that is 23.23% of the total area of the country (DNPWC, 2011). Distribution of PAs is depicted in Table 2.1.

Table 2.1 Protected areas and their extent to different physiographic regions

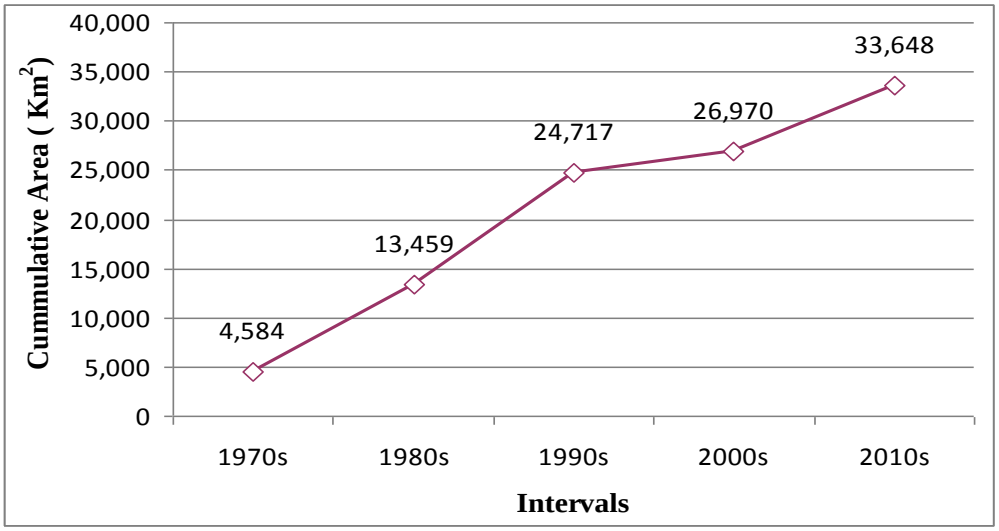
Category of PA	Name of the PA	Estd.	Area (km^2)	Physiographic region				
				T	S	MM	HM	HH
National Parks (10)	Banke National Park	2010	550	*	*			
	Shivapuri National Park	2002	144			*		
	Makalu Barun National Park	1991	1,500				*	*
	Sagarmatha National Park	1976	1,148					*
	Rara National Park	1976	106				*	
	Bardia National Park	1976	968	*	*			
	Langtang National Park	1976	1,710				*	*
	Chitwan National Park	1973	932	*	*			
	Khaptad National Park	1984	225			*	*	
	Shey-Phoksundo National Park	1984	3,555					*
Wildlife Reserve (3)	Koshi Tappu Wildlife Reserve	1976	175	*				
	Parsa Wildlife Reserve	1984	499	*	*			
	Shuklaphanta Wildlife Reserve	1976	305	*				
Hunting Reserve (1)	Dhorpatan Hunting Reserve	1987	1,325				*	*
Conservation Area (6)	Black Buck Conservation Area	2009	17	*				
	Manaslu Conservation Area	1998	1,663					*
	Kanchenjunga Conservation Area	1997	2,035				*	*
	Api Nappa Conservation Area	2010	1,903				*	*
	Gaurisankar Conservation Area	2010	2,179				*	*
	Annapurna Conservation Area	1986	7,629				*	*
Buffer Zone Area (12)	Chitwan NP Buffer zones	1996	750	*	*			
	Bardia NP Buffer zones	1996	507	*	*			
	Langtang NP Buffer zones	1998	420				*	*
	Shey-Phoksundo NP Buffer zones	1998	1,349				*	*
	Makalu Barun NP Buffer zones	1999	830				*	*
	Sagarmatha NP Buffer zones	2002	275				*	*
	Rara NP Buffer zones	2006	198				*	*
	Khaptad NP Buffer zones	2006	216			*	*	
	Banke NP Buffer zones	2010	343	*	*			
	Suklaphanta WLR Buffer zones	2004	244	*				
	Parsa WLR Buffer zones	2005	298	*	*			
	Koshi Tappu WLR Buffer zones	2004	173	*				

Note: T=Tarai, S= Siwaliks, MM=Middle Mountain, HM=High Mountain, HH=High Himal (Source: DNPWLR, 2012)

Although the area of PAs is expanding continuously, how adequately the PAs system is representing biodiversity protection is not analysed comprehensively (see Table 2.1). It is often

claimed that PAs are not adequately representing all parts of physiographic regions, altitudinal zones and eco-regions.

Figure 2.1 Expansion trend of PAs



2.4.1 Physiographic representativeness

The physiographic regions are not well represented in PAs and found to be extremely uneven and inequitable. Trisurat (2007) points out that a physiographic region is said to be well represented by PA, if the proportionof the area of PAs in the region is greater or equal to the proportion of the regions with respect to the area of the country A study undertaken by Shrestha et al. (2010), have demonstrated that High Himal is well represented (CI=2.95); however, the Middle Mountain are significantly unrepresented (CI= 0.03) in the current PAs. The Tarai (CI=0.42), High Mountain and the Siwaliks are moderately unrepresented. The main reason for this is that many conservation areas have been established on an *ad hoc* basis (Heinen & Shrestha, 2006; Shrestha et al., 2010).

Table 2.2 The extent of PAs representing biodiversity conservation across the physiographic regions

Physiographic zone	Total area (in Km^2) (with %)	Total PA area (in Km^2) (with %)	% of PA in the Physiographic zone	Comparison index[2] (CI)
High Himal	35,412 (24)	21,238 (71)	59.97	2.95

[2] Comparison index measures the extent of representativeness in the protected forest. A CI index is calculated by dividing the proportion of protected areas in a particular physiographic region by that category's share of the country's total land area (Trisurat, 2007). In general value greater than 1 indicates good representation, and a CI less than 1 indicate poor representation.

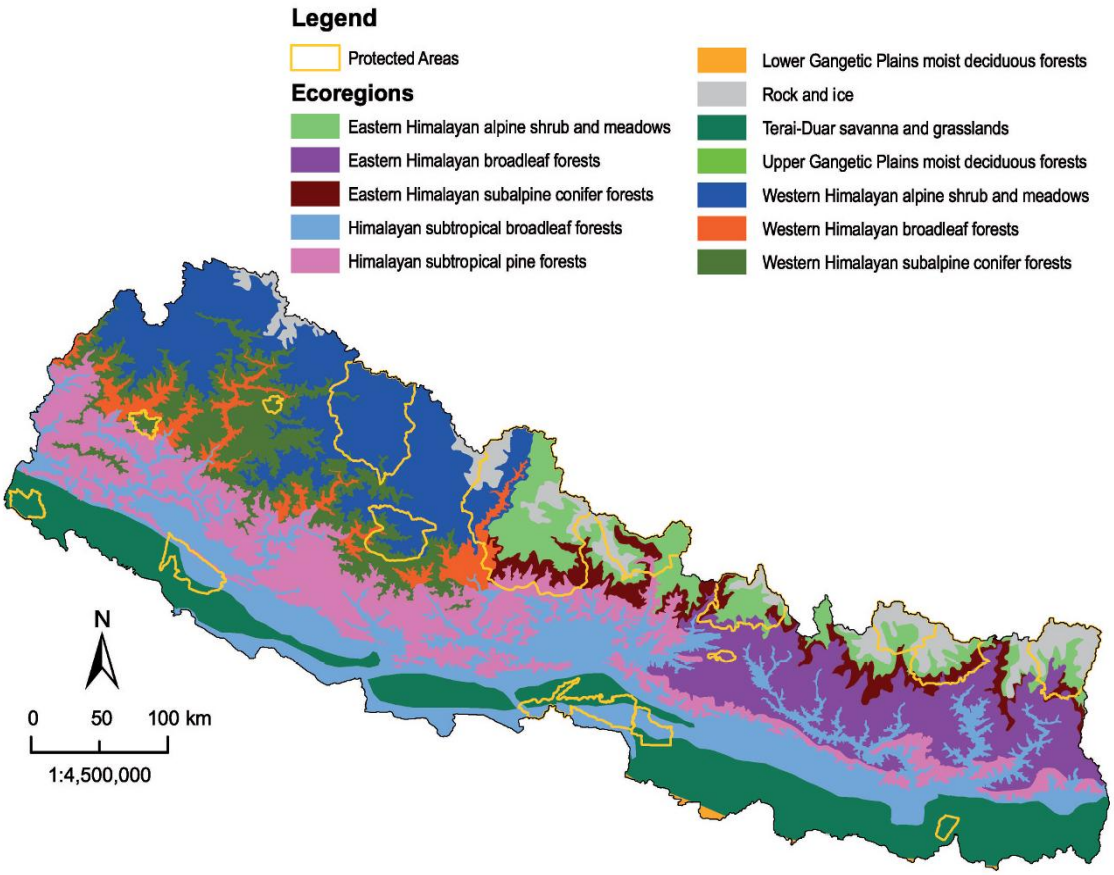
High Mountain	30,149 (20)	3,675 (12)	12.19	0.60
Middle Mountain	43,179 (29)	335 (1)	0.78	0.03
Siwaliks	19,010 (13)	3,015 (10)	15.86	0.76
Tarai	20,272 (14)	1,656 (6)	8.17	0.42
Total in Nepal	148,024	29,919* (100)	-	-

* This area does not include buffer zone area.

2.4.2 Eco-regions representativeness

Besides the physiographic representation, it is claimed that the PAs are unable to represent eco-regions. Nepal is endowed with 12 out of 867 terrestrial eco-regions across the globe, of which PAs only represents 10 eco-regions. Figure 2.2 shows the eco-regions and their position across the country and a list of eco-regions and their respective elevation is given at **Appendix** H.

Figure 2.2 Eco-regions of Nepal



Adopted from Shrestha et al., (2010)

According to Shrestha et al., (2007) the lower Gangetic Plains moist deciduous forests and the Upper Gangetic Plains moist deciduous forests are not represented by current PA network. On

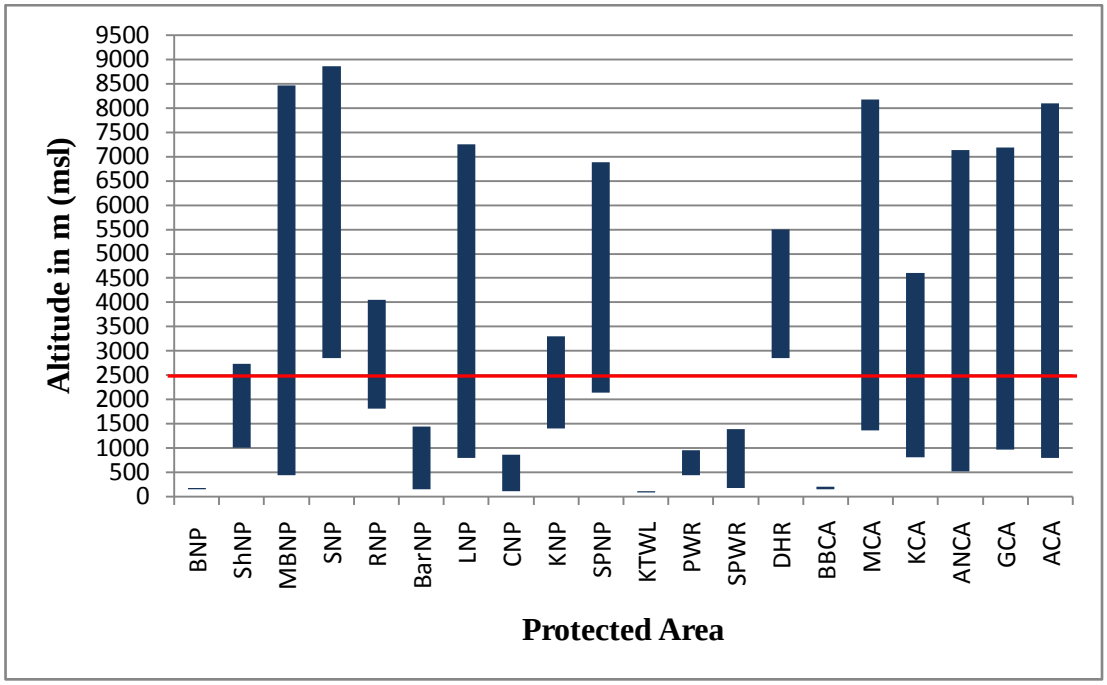
the other hand, the Eastern Himalayan alpine shrub and meadows eco-region has the highest representation and Himalayan subtropical pine forest has the lowest representation. PAs well represent the Eastern Himalayan subalpine conifer forests, rock and ice and the Western Himalayan alpine shrub and meadows eco-regions. The Eastern Himalayan broadleaf forests, Himalayan subtropical broadleaf forests, Tarai-Duar savanna and grasslands, Western Himalayan broadleaf forests and Western Himalayan conifer forests are poorly represented. A digital elevation model (DEM) showed that Himalayan subtropical broadleaf forests, Tarai-Duar savanna and grassland, and Western Himalayan broadleaf forests are treated as critically endangered and Western Himalayan subalpine conifer forest is vulnerable. A well represented Eastern Himalayan subalpine conifer forests has also vulnerable status. The eco-regions which have high global priority have low representation in PA system of Nepal.

2.4.3 Elevation representativeness

In Nepal, plant species richness varies significantly along elevation gradients, showing a strong correlation between altitude and species richness. Various studies have indicated that plant species richness increases up to certain elevation and reaches its maximum at a certain point and then falls (Bhattarai & Vetaas, 2003; Grau et al., 2007; Hunter & Yonzon, 1993). Species richness of flowering plants increases from 1000 m and reaches its maximum between 1500 and 2500 m and decrease thereafter (Vetaas & Grytnes, 2002). The strong relationship between altitude and species richness holds value in the conservation of genetic resources. To make PA network more representive in terms of plant species, it is essential to establish PA covering a wide range of altitude. However, an analysis showed that the current network of PAs are unable to cover the entire range of altitudinal gradient (Shrestha et al., 2010). The PAs are found to be extremely uneven and inequitable and they are skewed towards the high altitude region. The regions between 1000-2800 m are poorly represented in the existing PA network. The regions higher than 2800 m in altitude are well represented by PAs, on the other hand, lower altitude regions are inadequately included (Shrestha et al., 2010) (see Figure 2.3). Possibly this is the reason for underrepresentation of 39.62% of flowering plants in PAs. Inadequate data due to lacks of thorough assessment in PAs could be the reason for this underrepresentation. This demands detail floral analysis of PAs in future.

Although the PAs are disproportionately distributed across the physiographic regions, they occupy the area from plain Tarai to snow packed High Himal regions. Table 2.1 shows the PAs' distribution across the physiographic regions. In addition, the PAs systems have enclosed a wide range of vegetations associated with almost entire range of altitude. For example, Makalu Barun National Park includes diverse vegetation which ranges from 500 m (msl) to 8463 m (msl). Figure 2.3 illustrates the vertical range of each PA as marked by altitudinal limits.

Figure 2.3 Altitudinal Range of PAs of Nepal



Note; BNP= Bardia National Park, ShNP= Shivapuri National Park, MBNP= Makalu-Barun National Park, SNP= Sagarmatha National Park, RNP= Rara National Park, BarNP= Bardia National Park, LNP=Langtang National Park, CNP=Chitwan National Park, KNP= Khapatad National Park, SPNP= Shey-Phoksundo National Park, KTWL= Koshi Tappu wildlife Reserve, PWR=Parsa Wildlife Reserve, SPWR= Shuklaphanta Wildlife Reserve, DHR= Dhorpatan Hunting Reserve, BBCA= Black Buck Conservation Area, MCA= Manaslu Conservation Area, KCA= Kanchenjunga Conservation Area, ANCA= Api Nappa Conservation Area, GCA= Gaurisankar Conservation Area, ACA= Annapurna Conservation Area.

2.4.4 Species, Forest and ecosystems types representation in PAs

The forest types of the Mid-hills are poorly represented by the PA system. An analysis shows that the Tarai region comprises 14.82% (3,957 km^2) of the country's PA system, mid hills only 6.74% (1,800 km^2) and high mountains 78.44% (20,939 km^2), but the middle mountains are most diverse in terms of biodiversity. PAs, however, do not alone enclose all the important biological resources.

As mentioned earlier 118 types of ecosystems are identified in Nepal, and only 80 ecosystems are included in PA system (see Table 2.3) (Bhuju et al., 2007). **Appendix I** shows the distribution of ecosystems in different PAs. Regarding the plant species, PA system only represents 2,532 species of 1,034 genera and 199 families (Bhuju et al., 2007). This figure could increase because four other conservation areas have been established thereafter.

Table 2.3 Ecosystems within PAs systems

Physiographic Zone	No. of PAs	No. of Total Ecosystems	Number of Ecosystems in PAs
Tarai	7	10	10
Siwaliks		13	5
Middle Mountain	4	52	33
High Mountain			
High Himal	9	43	32
Total	**20**	**118**	**80**

Source: Bhuju et al.,(2007)

Of the total ecosystems, Tarai and Siwaliks contained 23, of which 15 of them are included in the current PAs. However, the forest resources outside the PAs are under severe human pressure. The Biodiversity Profile Project (BPP, 1995) has mentioned 1,885 species of angiosperms, 61 species of bryophytes, and 81 species of pteridophytes in these regions. Among the total PAs in Nepal seven of them lie in Tarai and Siwaliks regions. This count of the flora was taken long ago; most of the exploratory works had been undertaken in the Middle Mountain and High Mountain region.

Middle Mountain regions have the greatest ecosystem as well as species diversity of all the physiographic regions. However, PA system represents only few of the ecosystems which lies in the Middle Mountain. It is estimated that the Middle Mountain region constitutes 53 types of ecosystems, 33 of them are included in PAs. The main concern is with regard to broadleaf forests in between about 1000-3000 m in elevation (Heinen & Shrestha, 2006). According to Biodiversity Profile Project (BPP, 1995) 3,364 species of angiosperms, 493 species of bryophytes, 272 species of pteridophytes and 16 species of gymnosperms are found in this region. High Mountain and High Himal represent 32 of the 43 ecosystems of the region. They are nevertheless characterized by a large number of endemic species.

Realizing that not all the ecosystems are included in PAs, the protection of those ecosystems has increasingly become important. Establishing new PAs is less likely because it may involve large amount of social and economic costs (Brown, 1998). Therefore, it is essential to find alternative ways to ensure the protection of middle hill ecosystems with lesser social and economic costs. To this end, community forestry program could be a potential alternative, as this program is well extended in all parts of the country. Many studies have indicated that community forest user groups have adequately conserved biodiversity resources (Adhikari et al., 2004; Nagendra, 2002). For this purpose, first identify the community forest which contains the ecosystems that are not enclosed in PAs and then prepare plan according to forest users' interest and aspiration.

2.5 *In situ* conservation outside the PAs

2.5.1 On-farm conservation

On farm conservation is an emerging new concept adapted by many government and non-government sectors in the developing countries. Many studies have indicated that considerable number of species maintained in agriculture farm as a part of subsistence farming. Adequate attention for conservation has not been given to these resources. The role of these tree species in biodiversity conservation has been well documented (Acharya, 2006; Amatya & Newman, 1993; Fonzen & Oberholzer, 1985). Many of the species are only found in agriculture land and some of them are threatened (Acharya, 2006). Study such as by Acharya (2006) have recorded *Michelia champaca, Acacia catechu, Choerospondias axillaris, Butea monosperma, Elaeocarpus sphaericus* are threatened and are existing in farm land. A list of tree species which are commonly found in the Middle Mountain farmland is shown in Table 2.4.

Table 2.4 Tree species conserved in the farmland

Species	***Species***	***Species***
Abutilon indicum	*Cinnamomum tamala*	*Madhuca indica*
Acacia catechu	*Citrus* species	*Madhuca longifolia*
Adina cordifolia	*Cryptomeria* species	*Mallotus phillipinensis*
Aegle marmelos	*Dalbergia sissoo*	*Mangifera indica*
Albizia species	*Delonix regia*	*Melia azederach*
Alstonia scholaris	*Dendrocalamus* species	*Michelia champaca*
Annona squomosa	*Elaeocarpus sphaericus*	*Morus alba*
Anthocephalus chinensis	*Erithrina variegata*	*Myrica esculenta*
Artocarpus heterophyllus	*Ervatamia cronaris*	*Nyctanthes arbor-tristis*
Artocarpus integra	*Eucalyptus* species	*Phoenix doctylifera*
Artocarpus lakoocha	*Ficus auriculata*	*Phyllanthus emblica*
Saraca indica	*F. bengalensis*	*Pinus roxburghii*
Azadirachta indica	*F. cunia*	*Premna integrifolia*
Bambusa spp.	*F. elliptica*	*P. latifolia*
Bassia butyracea	*F. glomerata*	*Prunus cerasoides*
Bauhinia purpurea	*F. lacor*	*Psidium guava*
Bauhinia variegata	*F. recemosa*	*Quercus* species
Bombox ceiba	*F. religiosa*	*Rhus succedanea*
Borassus flabellifer	*F. rhumpi*	*Ricinus communis*
Bredelia retusa	*F. roxburghii*	*Saraca indica*
Butea monosperma	*F. semicordata*	*Schima wallichii*
Callistemon viminalis	*Fraxinus floribunda*	*Syzygium cuminii*
Cassia fistula	*Garuga pinnata*	*Tamarindus indica*
Castanopsis indica	*Gmelina arborea*	*Tectona grandis*
Castanopsis tribuloides	*Gravelia robusta*	*Terminalia belerica*

Ceiba pentandra	*Jacaranda ovalifolia*	*T. tomentosa*
Celtis australis	*Juniperus wallichiana*	*T. chebula*
Choerospondias axillaris	*Leucaena leucocephala*	*Trewia nudiflora*
Chrysanthemum coranarium	*Litchi chinensis*	*Ziziphus jujuba*
Cinamomum zeylanicum	*Litsea polyantha*	
Cinnamomum camphora	*Machilus* spp.	

Sources: Acharya (2006), Kharal, Giri & Karna (2008), GoN (2007)

The challenges and constraints relating to the *in situ* conservation in farm land are as following.

- Lack of monetary resource is the main constraints to design and implement *in situ* conservation in farm land.
- No detail study related to status of these resources has been carried out except some case studies.
- Despite the role of *in situ* conservation of forest genetic resources for future improvement in production, the policy makers are less informed and aware of its benefits.
- Lack of policy relating to how the benefits of privately owned farm trees for the rural farmers can be increased.

Awareness creation, setting up of farmers organizations for production and marketing of tree products, and extension programs for the planting and management of farm trees, better access to seedlings, and removal of the felling ban for farm trees and provide incentives for tree planting and management are some of the activities that could contribute to increase the conservation and utilization of forest genetic resources in farm land.

2.5.2 Conservation through the establishment of protection forests

The Department of Forests has recently started to declare the protection forests to conserve the unique biodiversity, ecosystems and genetic resources of the some of government managed forests. Government has already prepared and implemented the five years management plans of seven protected forests distributed in the Tarai and Mid-hills of the country (DoF, 2012). Table 2.5 shows areas of protected forests and important tree species found in these forests.

Table 2.5 Protected Forests of Nepal

SN	Protected Forest	Area (ha)	Districts	Tree species
1.	Laljhadi-Mohana	29,642	Kanchanpur, Kailali	*Shorea robusta, Terminalia* spp., *Pterocarpus marsupium, Dalbergia sissoo, Adina cordifolia, Acacia catechu* etc.
2.	Basanta	69,001	Kailali	*Shorea robusta, Terminalia* spp., *Adina cordifolia, Dalbergia sissoo, Pinus roxburghii* etc.
3.	Khata	4,504	Bardia	*Shorea robusta, Terminalia* spp., *Adina cordifolia, Dalbergia sissoo, Bombax ceiba, Albizzia* spp. etc.
4.	Kakrebihar	176	Surkhet	*Shorea robusta, Terminalia* spp., *Pinus roxburghii* etc.
5.	Barandabhar	10,466	Chitwan	*Shorea robusta, Terminalia* spp., *Adina cordifolia, Dalbergia sissoo* etc.
6.	Panchase	5,776	Kaski, Parbat, Syangza	*Shorea robusta, Terminalia* spp., *Adina cordifolia, Bombax ceiba, Albizzia* spp., *Dalbergia sissoo* etc.
7.	Madhane	13,761	Gulmi	*Schima wallichii, Castenopsis* spp., *Pinus roxburghii, Alnus nepalensis, Quercus* spp., *Rhododendron* spp. etc.
Total		1,33,325		

Source: Department of Forests (2012)

2.5.3 *In situ* conservation establishing seed stands

Because not all the ecosystems, forests, and species are enclosed in PAs, forest genetic resources are conserved outside the PAs adopting other approaches. One of them is the establishment of seed stand for the species which are threatened, rare and endemic. *In situ* conservation of important species is upheld in the form of seed production areas. Seed stands have been established for dual objectives; to supply seed and to conserve the species at their native habitat. Government regularly declares seed stand for the species which are economically, and socially important. In addition, seed stand for threatened species is also set up. The list of the species for which seed production areas have been established is listed in **Appendix J.** The seed stands are extended throughout the country.

2.5.4 *In situ* gene conservation area

Besides seed stands, efforts to conserve of genetic resources in their native environment have been carried out by establishing conservation area for the species which are assumed to be threatened. Gene conservation area is mainly created to save the loss of gene complexes and gene-type and in extreme condition to prevent the extinction of whole taxonomic categories. Up until 2011, government has established *in situ* conservation area for only three species; *Dalbergia latifolia* (80 hectare) and *Pterocarpus marsupium* (100 hectare) and *Rhododendron*

species (585 Km^2). *Dalbergia latifolia* and *Pterocarpus marsupium* possess threatened status. Due to a high commercial value of these two species for their timber, the wild population of them have been widely exploited. The distribution of these species is narrowing because of habitat reduction, poor nature of their regeneration and the process of indiscriminate and illegal harvesting which are still continuing.

Rhododendron species conservation area is of special interest, because the area host highest number of *Rhododendron* species in the country. In addition, the area is culturally significant and is popular tourist destination for mountaineering, trekking and rafting. For details of the conservation area see Box 1.

Box 1. Tinjure-Milke-Jaljale Rhododendron Conservation area

Area set aside for Rhododendron is Tinjure-Milke- Jaljale (TMJ) Rhododendron Conservation Area. The area covers parts of *Sankhuwasabha*, *Taplejung* and *Tehrathum* districts. It is 585.26 ha in area and it has been managed under Ministry of Environment, Science and Technology. This conservation area was set up to conserve Rhododendron species. This area alone has 28 species of Rhododendron.

Table 2.6 shows the list of Rhododendron species found in Nepal. No other area in the world and even Nepal has such large number of Rhododendron in one block of forest (Adhikari, 2011). The area also called capital of Rhododendron (IUCN, 2010). Despite the fact that the TMJ important for conservation point of view, the area has not improved as such. The increased settlement, encroachment, cattle grazing and road construction in the area are threatening Rhododendron species. The area should be declared conservation area and management should be carried out through the community. The community should be given right so that they would improve their economic condition along with conservation work.

Table 2.6 Rhododendron species found in Nepal

SN	Species	Tree /Shrub	SN	Species	Tree /Shrub
1	*Rhododendron anthopogon*	S	15	*R. hodgsonii*	T
2	*R. arboreum*	T	16	*R. lapponicum*	S
3	*R. barbartun*	T	17	*R. lepidotum*	S
4	*R. cameliiflorum*	S	18	*R. lindleyi*	T
5	*R. campylocarpum*	S	19	*R. lowndesii*	S
6	*R. campanulatum*	S	20	*R. nivale*	S
7	*R. cinnabarinum*	S	21	*R. nudiflorum*	S
8	*R. cowanianum*	S	22	*R. pumilum*	S
9	*R. dalhousiae*	S	23	*R. setosum*	S
10	*R. falconeri*	T	24	*R. thomsonii*	S
11	*R. fulgens*	S	25	*R. triflorum*	S
12	*R. grande*	T	26	*R. vaccinioides*	S
13	*R. glaucophyllum*	S	27	*R. wallichii*	S
14	*R. griffithianum*	T	28	*R. wightii*	T

Source: Noshiro & Suzuki (2001)

In spite of government's efforts for the management of gene conservation areas, no significant improvement has been observed in these *in situ* conservation areas. This is mainly because of intensive human pressure and high economic value of these species. Besides these two species there are many other forest species as well which are genetically threatened, and need to be conserved.

Besides, mapping the geographical distribution of the species which are on the verge of extinction is very essential. Detail surveys regarding status of the forest tree species has not been carried out for long period. Even the list of the plant species protected by CITES has been remained unchanged since 1973 due to the absence of scientific review (Chaudhary, 2000). The status of threatened species within the PAs has not been explored yet. In this circumstance, detail floral inventory including the PAs is paramount important. It has been observed that the conservation outcome of species is relatively better in the forests which have been managed by community. Seeing this performance, it became essential to start *in situ* conservation in community managed forest in addition to other form of management regimes.

2.5.5 Future potential and strategies for *in situ* conservation

Economic benefits from *in situ* forest genetic resources could sustain its conservation. One option is the biodiversity prospecting of forest genetic resources which are conserved *in situ*. Biodiversity prospecting is the exploration of biodiversity for commercially valuable genetic and biochemical resources. Besides the currently adopted approaches for *in situ* conservation, new approaches such as landscape level conservation, forest gene bank could be potential.

Landscape level conservation

Other approach of conserving forest genetic resources is the landscape level conservation of resources. The approach emerges in respons to ever increasing local needs and likely pressure these may have on the ecosystem. In this regards government has begun to manage forest genetic resources at the landscape level. The landscape management objectives, however, are more focused to wildlife and pay little attention to the conservation of forest flora. Many forest tree species which are in the brink of extinction are found in landscape level areas.

Forest gene bank

The approach of forest gene bank is related to conservation of total genetic diversity of particular species, among the population as a unit. Conceptually forest gene bank serve as the *in situ* bank in which genes from as many diverse population are conserved. Operationally, in these *in situ* banks, genes from the entire population are collected and conserved which serves as a sink into which genes from distinct source is introduced. So far this approach has not been employed in Nepal, and it could be useful given the resources that the country have for forest genetic resource conservation. At least gene bank for the economically and threatened species could be the good start. Gene bank could form an important step forward in the effort to resurrect the genetic diversity of the forest trees, especially of those which are brink of extinction.

There is relative gap of technical knowledge on establishing forest gene bank concept in Nepal. Hence, it is essential to build the capacity of the government staff of forest gene bank establishment. Along with capacity building, policy and guideline have to be prepared.

Chapter 3

The State of *ex situ* Genetic Conservation

3.1 Introduction

Ex situ conservation deals with the conservation of genetic resources outside their native habitats.. Often *ex situ* conservation is applied as an additional measure to supplement the *in situ* conservation. The main *ex situ* conservation approach include botanical gardens, tissue culture, storage of orthodox/recalcitrant seeds and vegetative material in gene bank facilities with extremely low temperature and germplasm conservation. Despite widespread use of *ex situ* conservation, they have limited application, because *ex situ* approach only conserve limited number of species with narrow genetic variability. Mostly, this method is considered as static approach, as it is conserved in the gene banks and discards adaptive changes. No adaptive changes of genetic structures are possible during the storage period of seeds or other germ plasm.

Ex situ conservation is best suited to ensuring the conservation of species or population on the face of extinction in their natural habitat. *Ex situ* conservation does not serve as the substitute for the conservation of variability of the natural population and it is costly for forest tree species. Considering the importance of *ex situ* conservation in forest genetic conservation endeavour, this Chapter describes the current state of *ex situ* conservation of forest genetic resources in Nepal. Needs, priorities and constraints in undertaking *ex situ* conservation in the country are also explained.

3.2 *Ex situ* conservation initiatives

Despite the conservation of forest genetic resources in their native habitats, efforts are being made towards *ex situ* conservation. *Ex situ* conservation in Nepal basically focuses on the conventional approaches. Some examples of *ex situ* conservation are tissue culture, breeding seedling orchards (BSOs), botanical gardens and gene bank. Institute of Forestry has established a pinnatum at their premises in Hetauda to conserve and study the pine forests from different regions in a single place.

3.2.1 Tissue culture laboratories

Tissue culture technology has been used in Nepal considering the limitation in seed supply of economically important and threatened forest tree species. There is one plant tissue culture laboratory at National Herbarium and Plant laboratories, Godawari which was established in 1976. The Department of Plant Resources runs the tissue culture laboratory. This laboratory has been engaged in the development of tissue culture techniques for the propagation of economically important and endangered plant species of Nepal. Over the period, 115 plant

species have been cultured and scientific protocols have been developed including orchids, agricultural, horticultural, forestry, ornamental and medicinal plants (DPR, 2010). In addition to the development of protocol for micro-propagation of important plants, the laboratory has also been engaged in providing training on basic technique of plant tissue culture to the interested persons. The forest tree species for which tissue culture has been undertaken is given in Table 3.1. The most remarkable achievement of this laboratory has been the development of sand rooting technique in which the tissue-cultured micro shoots can be rooted in non-sterile sand. Sand rooting technique is easy, cheap, less time consuming, economic, and conveniently done in nurseries, and can be easily established for field plantation.

Table 3.1 Tissue cultured forest tree species

SN	Species	SN	Species
1	*Acacia auriculiformis*	12	*Ficus auriculata*
2	*Artocarpus lakoocha*	13	*F. carica*
3	*A. hetrophyllus*	14	*F. elastica*
4	*Azadiracta indica*	15	*F. lacor*
5	*Dalbergia sissoo*	16	*F. nemoralis*
6	*Dendrocalamus hamiltonii*	17	*F. religiosa*
7	*Dendrocalamus strictus*	18	*F. semicordata*
8	*Elaeocarpus sphaericus*	19	*Morus alba*
9	*Eucalyptus camaldulensis*	20	*Populus ciliata*
10	*E. citridora*	21	*Santalum album*
11	*E. teretocornis*	22	*Paulownia* species

The Department of Plant Resources has recently established a Biotechnology Laboratory at its premises for the further strengthening of the tissue culture activities in the pilot scale. Besides this, Nepal Agriculture Research Council (NARC) has been doing tissue culture for vegetable species. The private sectors like Tissue Culture Laboratory, Nepal Biotech Nursery, Botanical Enterprises and Micro Plant Nepal have been engaged in tissue culture activities for commercial production, mainly for ornamental and horticulture plants.

3.2.2 *Ex situ* conservation through Breeding Seedling Orchards

The TISC under DoF also undertakes *ex situ* conservation activities. TISC has established breeding seed orchards in different district to conserve the genetic resources of many species such as *Dalbergia sissoo* and *D. latifolia.* TISC is also promoting the identification, registration and management of local seed sources. The main aim of BSOs is to make each district self-sufficient in seed supply of highly demanded species and to conserve plant genetic resources. Table 3.2 provides the list of forest species which are under *ex situ* conservation.

Table 3.2 Species under *ex situ* conservation

Species			Field collections				Germplasm bank	
Scientific name	**N / E**	Area (ha)	**Collections, provenance or progeny tests, arboreta or conservation stands**		**Clone banks**		***In vitro* (including cryo conservation)**	
			No. banks	**No. clones**	**No. banks**	**No. acc.**	**No. Banks**	**No. acc.**
Aegle marmelos	N						1	1
Abies spectablilis	N						1	1
Albizia chinensis	N	1.00	1				1	1
Anthocephalus cadamba	N	1.47	1					
Artocarpus lakoocha	N	0.83	2	-	-	-		
Azadirachta indica	N	1.04	1				1	1
Bassia butyracea	N	1.99	2					
Bauhinia purpurea	N	0.41	1					
Bauhinia variegata	N	0.87	1				1	NA
Bombax ceiba	N	1.00	1					
Butea monosperma	N							
Cassia fistula	N	1.00	1					
Choerospondias axillaris	N	2.28	2					
Cinnamomum camphora	N						2	2
Cinnamomum tamala	N		3				1	1
Dalbergia latifolia	N	11.3	1					
Dalbergia sissoo	N		7					
Elaeocarpus sphaericus	N	-	-	-	-	-	1	1
Phyllanthus emblica	N	1.00	2	-	-	-		
Ficus semicordata	N	1.43	1					
Gmelina arborea	N	0.87	1					
Juniperus squamata	N							
Leucaena leucocephala	N	0.40	3					
Madhuca longifolia	N	1.00	1					
Michelia champaca	N	1.30	2		-	-	1	1
Pinus roxburghii	N							1
Pterocarpus marsupium	N	2.50	1				1	NA
Rhododendron spp.	N						1	1
Santalum album	N						1	1
Tamarindus indica	N	1.00	1					
Taxus walllichiana	N							3
Tectona grandis	E	1.00	1					
Terminalia arjuna	N						2	1
Terminalia bellerica	N		-				2	1
Zanthoxylum armatum	N	1.00	1					

Note: N=Native, E=Exotic, No.=Number

3.2.3 *Ex situ* conservation through botanical gardens

The establishement of botanical garden is another popular example of *ex situ* conservation. Botanical gardens have been established for both *ex situ* as well as *in situ* conservation in some cases. The gardens are established in different part of the country ranging from Tarai to High Mountain. It has been observed that only few species are conserved in present networks of botanical garden in the country.

The government has established 11 botanical gardens in different physiographic regions with focus on landscape development for education and research, aesthetic and recreational purposes. The botanical gardens are conserving nationally listed threatened, endemic and endangered species. Apart from locally found tree species, botanical gardens located Tistung also houses medicinal plants. Details regarding the list of botanical gardens are given in Table 3.3. Godavari botanical garden (82 ha) is the country's central botanical garden located near the capital city. It houses nearly 300 species of plants including 89 species of trees, 26 species of shrubs, 140 species of herbs including 90 species of orchids, 12 species of climbers, and 31 exotic trees and shrubs.

Table 3.3 Germplasm of forest tree species conserved at different botanical gardens

SN	Name of Botanical garden	District	Est. (yr)	Region	Alt(m)	Tree species
1	Daman Botanical Garden	Makawanpur	1962	HM	2,140	
2	Deoria Botanical Garden	Kailali	1998	T	100	*Cinnamomum tamala, Terminalia arjuna, Santalum album, Aegle marmelos*
3	Dhakeri Botanical Garden	Banke	1990	T	130	*Terminalia belerica, T. arjuna, Cinnamomum camphora*
4	Dhanusha Botanical Garden	Dhanusha	1998	T	100	*Terminalia belerica, T. chebula, Bauhinia purpurea, Pterocarpus marsupium*
5	Dhitachaur Botanical Garden	Jumla	1990	HM	2,500	*Taxus wallichiana, Juniperus squamata*
6	Godawari Botanical Garden	Kailali	1998	T	200	*Pterocarpus marsupium, Butea monosperma, Elaeocarpus sphaericus*
7	Maipokhari Botanical Garden	Ilam	1992	MM	2,200	
8	Mulpani Botanical Garden	Salyan	1990	MM	2,000	*Machilus* spp.
9	National Botanical Garden	Lalitpur	1962	MM	1,500	*Choerospondias axillaris, Myrica esculenta*
10	Tistung Botanical Garden	Makawanpur	1962	HM	1,700	
11	Vrindaban Botanical Garden	Makawanpur	1962	S	500	*Michelia champaca, Azadirachta indica, Albizia* spp.

T=Tarai, S=Siwaliks, MM=Middle Mountain, HM=High Mountain, MSL=Mean Sea Level, Est.=Established, yr.=year, Alt.= Altitude, NA=Not available

The botanical gardens represent the central and western Middle Mountain, Tarai-Siwalik regions, and the eastern Middle Mountain regions. The High Mountain regions and the Eastern Tarai-Siwalik regions are not represented in this network (Bhuju et al., 2007).

3.3 Infrastructure capacity for *ex situ* conservation

Infrastructure capacity of the country regarding *ex situ* conservation is very limited. Only a few government agencies are equipped with tissue culture facility. Government owned National Herbarium and Plant Laboratory is the first laboratory which started tissue cultures in 1976. This laboratory basically has been doing clonal propagation of hard wood trees, horticulture crops, medicinal plants, ornamental plants and over 30 kinds of orchids. Table 3.4 provides names of the institutions engaged in *ex situ* conservation through tissue culture.

In recent years, some private institutions equipped with laboratories have established facilities to enable biotechnology related research in the country. The biggest laboratory in private sector is the Research Laboratory for Agricultural Biotechnology and Biochemistry which was established in 1986. However, the facilities remain unused at present. This laboratory has developed many biochemical techniques to create cold tolerant rice, sex-determination of deciduous plants and micropropagation of many plants like *Pine* and *Artocarpous*. Although there exists *ex situ* conservation facilities through tissue culture technology, the technology itself is still at a low profile.

Table 3.4 Institutions having tissue culture facility

SN	Name of Laboratory	Owner	Address	Facilities
1	Central Department of Botany, Tribhuwan University	AI	Kathmandu	Tissue culture propagation of different medicinal plants
2	Green Research and Technology (GREAT)	PR	Kathmandu	Virus testing and elimination facilities on horticultural crops
3	Himalayan Botanical Research Centre (HIMBORCE)	PR	Kathmandu	Lab. for micro propagation of medicinal and ornamental plants indigenous to Nepal.
4	Himalayan Floratech	PR	Lalitpur	Commercial application of plant tissue culture technology
5	Horticulture Development Project, Department of Agriculture	GO	Katmandu	Tissue culture laboratory
6	Institute of Agriculture and Animal Sciences, Tribhuwan University	AI	Chitwan	Lab. facility assisting thesis works for the students only
7	Lumle Agricutlure Centre	GO	Kaski	Tissue culture laboratory
8	Microplants Private Limited	PR	Kathmandu	Commercial propagation through tissue culture
9	National Herbarium and Plant Research Laboratory	GO	Kathmandu	Lab. for tissue culture research

10	Nepal Academy of Science and Technology	GO	Kathmandu	Lab. for molecular characterization
11	Nepal Agriculture Research Council (NARC)	GO-Autonomous	Kathmandu	Tissue culture laboratories and green house facilities
12	Nepal Biotech Nursery	PR	Kathmandu	Tissue culture and non-sterile sand rooting technique
13	Pakhribans Agricutlure Centre	GO	Dhankuta	Tissue culture laboratory
14	Research Centre for Applied Science and Technology (RECAST), Tribhuwan University	AI	Kathmandu	Lab. for biotechnology related research for the post graduate students
15	Research Laboratory for Agriculture Biotechnology & Biochemistry (RLABB)	PR	Kathmandu	Research and training related to Plant biotechnology

Note; PR= Private, AI= Academic Institution, GO= Governmental.

3.4 Actions for sustaining existing *ex situ* collections

The government could not pay adequate attentions towards sustaining existing *ex situ* conservation initiatives, due to insufficient human, technical know-how and financial resources. To safeguard the existing *ex situ* conservation activities, efforts are underway to involve concerned stakeholders in their use and management. Government has promoting the community seed banks in cooperation with various I/NGOs for agriculture and forest tree species. Most of the breeding seed orchards lie within government managed forest, but lack the proper care. Therefore, the government has been attempting to entrust the management responsibility of orchards to the local community by allowing the community to receive benefits from them. Despite the handing over to the community, sustainability of the orchards could not be ensured, because the communities have been unable to generate adequate benefits from the orchards. This is mainly because of lack of linkage with the market network. Hence, to enhance benefits, a linkage of these *ex situ* collections not only with agencies within the country but also with the international network is essential.

3.5 Constraints to improving *ex situ* conservation

There are numerous constraining factors for development of *ex situ* conservation in the country, the most noticeably are;

- lack of baseline information
- insufficient qualified human resource
- limited resource available for conservation activities
- lack of gene bank laboratory
- *ex situ* conservation receives relatively lower priority than the other programs, and
- scattered and undefined distribution of responsibilities among the different departments.

The government does not have detail information on the status of forest species and no such inventory has been carried out. The status of species so far is based on the case studies carried out by some academic institutions and people's perception. Hence, detail study on the status of the forest tree species is essential for planning future *ex situ* conservation activities.

The government has staff having with limited knowledge and skills on *ex situ* conservation. Even the existing human resources are involved in activities other than *ex situ* conservation. *Ex situ* conservation urgency has not been receiving adequate attention from the government.

3.6 Institutions involved in *ex situ* conservation

Three Departments under MFSC: Department of Forests (DoF), Department of Plant Resources (DPR) and Department of Forest Research and Survey (DFRS) are involved in *ex situ* conservation activities. Department of National Parks and Wildlife (DNPWL) is mainly working with *ex situ* conservation of wild fauna by establishing zoo, captive breeding and translocation of the endangered wildlife. The major activities of DoF and DFRS include identification, registration and management and establishment of breeding seed orchards in different parts of the country. The major goal of orchard is to conserve the genetic diversity of forest trees and to supply quality seeds on a reliable basis for the success of plantation programmes. DPR mainly performs activities related to botanical garden management. It is recognised that the lack of coordination among the departments is constraining the improvement of collections for *ex situ* conservation. The departments are doing *ex situ* conservation in their own ways.

3.7 Constraints expanding the *ex situ* conservation

The major constraints for expanding plant genetic resources *ex situ* collection are inadequate funds and trained human resources, lack of taxonomist, rapid pace of genetic diversity loss, insufficient equipment and lack of an implementation plan. In addition, there is lack of comprehensive inventory regarding the status of forest species. So far *ex situ* programs which have been launched are based on the IUCN list and the general public's, and forest technicians' perceptions.

3.8 Priorities for future *ex situ* conservation actions

Botanical gardens need expansion in terms of its number and capacity so as to include a wider variety of species. A botanical garden representing High Mountain forest species is essential as the existing botanical gardens do not include high Mountain species. Protection issue is also emerging on the existing BSOs set up so far by TISC and DFRS. These *ex situ* conservation areas are under great human pressure. It is interesting to note that the BSOs which were established in community forest area are relatively better than those which were established in

government managed forests. Better performance of the BSOs situating under community management guide the future policy regarding the BSOs establishment.

The other priority is the establishment and operation of the gene bank laboratory. The government has established a national gene bank laboratory under Nepal Agriculture Research Council (NARC) for *ex situ* conservation. However, this national gene bank has been used only to conserve agriculture genetic resources. Establishing another gene bank under MFSC would be essential and it is wise to utilize existing NARC facility for forest too. Further, promoting the seed bank cooperatives in the rural area could be the least expensive but much effective ways towards *ex situ* conservation of important forest tree species.

Considering the short supply of the seeds for the species, tissue culture is another viable option. Tissue culture for some of the species has already commenced. Tissue culture for other species and their distribution is also needed. Also, capacity development for the staff associated with tissue culture is also essential. The facilities in tissue culture laboratories are not up to that standard, hence improvement in the laboratory facilities is desirable. The government has established some *ex situ* conservation areas, however due to anthropogenic reasons the areas are under great pressure. In the situation, to ensure the conservation of the genetic resources, a genetic conservation laboratory is very essential to sustain the conservation programmes.

Chapter 4
The State of Use and Sustainable Management of Forest Genetic Resources

4.1 Introduction

The conservation of forest genetic resources is meaningful only if genetic potential of important species is harnessed and genetic diversity has been conserved for sustainable of forests and betterment of humankind. In this regard, the country has initiated many efforts at national and international levels. The forest genetic resources have been used in various ways for the economic development of the country. The government is striving to optimize the benefits from the resources. To increase benefits, improvement in genetic resources conservation is still necessary.

Taking into account the benefits of forest genetic resources, this Chapter describes the use and sustainable management of forest genetic resources. It indicates the needs and priorities for improving the genetic resources. The national, regional and international interventions that are being applied to sustain forest genetic resource conservation and use are also described. Specifically, this chapter explains the utilization of conserved forest genetic resources and major constraints to their use. State of forest genetic improvement and breeding programs, the state of use and management of forest reproductive materials; forest reproductive material availability, demand and supply, the state of current and emerging technologies and assessment of needs to improve the forest genetic resources management and use also will be explained.

4.2 Genetic improvement programmes and their implementation

Genetic improvement is essential to maintain the supply of forest products and sustain the genetic diversity of forest resources. In this regard, the government has implemented numerous activities, including establishment of Breeding Seedling Orchards, Seed Stand and Provenance Trial. TISC and DFSR are the two organizations under the MFSC responsible to implement tree improvement programs. Studies carried out by these organizations focus on identification and establishment of seed stands, provenance trial, progeny trial and Breeding Seedling Orchards for the economically valuable and threatened species.

4.2.1 Seed Stands

Seed stands are established in the native habitat of the species, and are established for the supply of good quality seeds. The establishment process includes identification of seed source and its registration. TISC's recent report shows that seed stands for 25 species in 95 sites have been

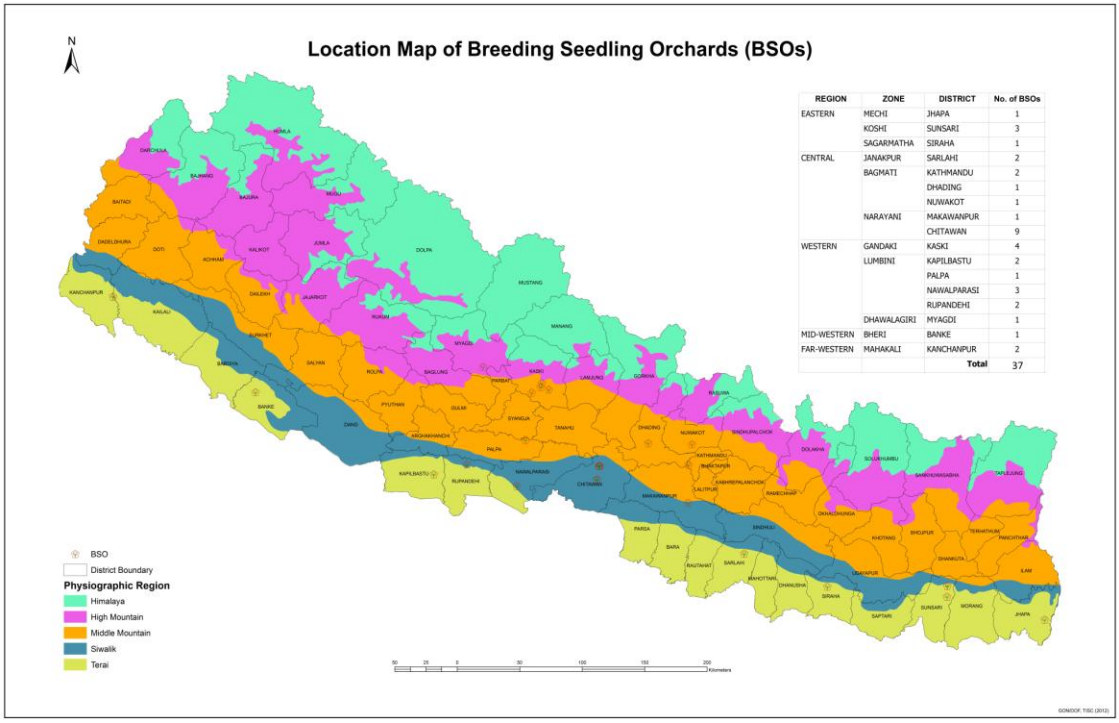
established in different districts (**Appendix K**). These seed sources are established taking into account their respective planting zones. The main aim of establishing seed stands are to make each district self sufficient in seed supply of highly demanded species and to conserve genetic resources. The planting zone for a species reflects its favourable site.

In Nepal, substantial hectares of forests are planted both from government and private sectors each year and these plantations are based on fairly few species. It is likely that demand for the plantation will be bigger in future. However, the current practice of species selection and plantation does not seem paying enough attention to the ecological factors for a species. Less attention is given to the choice of species for a given site and choice of seed for a given species. Successful tree plantation requires certain degree of ecological and technical skills. The species should be planted on the site where it is able to survive and grow and fulfil the requirements of the owners. In order to improve the plantation practices in Nepal, it requires identification of planting zones for the species which are widely used for economic and ecological benefits. TISC component has identified planting zones for four species which includes *Bauhinia purpurea*, *Brassaiopsis glomerulata*, *Ficus neriifolia* and *Garuga pinnata*.

4.2.2 Breeding Seedling orchards

Breeding Seedling Orchards (BSOs) are plantations specifically planted and managed for quality seed production. BSOs for 22 species have been set up in various parts of the country. Distribution of BSOs in the country is depicted in Figure 4.1.

Figure 4.1 Distribution of Breeding Seed Orchards



REGION	ZONE	DISTRICT	No. of BSOs
EASTERN	MECHI	JHAPA	1
	KOSHI	SUNSARI	3
	SAGARMATHA	SIRAHA	1
CENTRAL	JANAKPUR	SARLAHI	2
	BAGMATI	KATHMANDU	2
		DHADING	1
		NUWAKOT	1
	NARAYANI	MAKAWANPUR	1
		CHITAWAN	9
WESTERN	GANDAKI	KASKI	4
	LUMBINI	KAPILBASTU	2
		PALPA	1
		NAWALPARASI	3
		RUPANDEHI	2
	DHAWALAGIRI	MYAGDI	1
MID-WESTERN	BHERI	BANKE	1
FAR-WESTERN	MAHAKALI	KANCHANPUR	2
		Total	37

Most of the species are economically important (see Table 4.1). Most notable species include *Dalbergia sissoo, Ficus semicordata, Bauhinia variegata, Cinnamomum tamala, Bassia butyracea* and *Bauhinia purpurea*. BSO for some threatened species also has been established such as *Dalbergia latifolia, Choerospondias axillaris, Pterocarpus marsupium* and *Bombax ceiba.* The BSO for *Dalbergia sissoo, Leucaena leucocephala* and *Cinnamomum tamala* is replicated in more than two places owing to high economic importance of these species.

Table 4.1 Breeding Seed Orchards

SN	Species	Seed orchards*		
		Number	**Generation	Area (ha)
1	*Albizia lebbeck*	1	1st	1.00
2	*Anthocephalus cadamba*	1	1st	1.47
3	*Artocarpus lakoocha*	2	1st	0.83
4	*Artocarpus* species	1	1st	2.04
5	*Azadirachta indica*	1	1st	1.04
6	*Bassia butyracea*	2	1st	1.99
7	*Bauhinia purpurea*	1	1st	0.41
8	*Bauhinia variegata*	1	1st	0.87
9	*Bombax ceiba*	1	1st	1.00
10	*Cassia fistula*	2	1st	2.43
11	*Choerospondias axillaris*	2	1st	2.28
12	*Cinnamomum tamala*	3	1st	3.36
13	*Dalbergia latifolia*	1	1st	2.05
14	*Dalbergia sissoo*	7	1st	16.54
15	*Emblica officinalis*	2	1st	1.07
16	*Ficus semicordata*	1	1st	1.43
17	*Gmelina arborea*	1	1st	0.87
18	*Leucaena leucocephala*	3	1st	0.45
19	*Madhuca indica*	1	1st	1.00
20	*Pterocarpus marsupium*	1	1st	2.56
21	*Tamarindus indica*	1	1st	1.00
22	*Tectona grandis*	1	1st	1.00

**Generation refers to 1st, 2nd, 3rd, etc., breeding cycle

Regular annual measurement is carried in each BSOs. Mainly diameter, height, tree health and mortality are measured and recorded for analysis. Information regarding the tree improvement

programmes is being disseminated through various means mainly through reports, journal articles and leaflets. The findings on BSOs and other tree improvement programmes are mainly disseminated through a Journal published by the DFRS.

4.2.3 Tree improvement trials

Besides the BSOs and seed stands, provenance and progeny trials have also been undertaken in the country by TISC and DFRS. The details of tree improvement trials are given in Table 4.2. *Dalbergia sissoo* is the main species for which provenance trials have been conducted in various parts of the country. In addition, provenance trial of other important species such as *Eucalyptus* spp., *Azadirachta indica,* and *Bauhinia variegata* also have been carried out. To meet the demand of forest user group and private farmers, a clonal bank of *Eucalyptus camaldulensis* for mass multiplication has been also established.

Table 4.2 Tree Improvement trials

Species		Plus trees*	Provenance trials		Progeny trials		Clonal testing and development			
Scientific name	Native or Exotic	No.	No. of trials	No. of prov.	No. of trials	No. of families	No. of tests	No. of clones tested	No. clones selected	No. clones used
Azadirachta indica	N		1	23						
Bauhinia purpurea	N	32								
Bauhinia variegata	N	16	1	NA						
Choerospondias axillaris	N						1			
Dalbergia sissoo	N		3	12	1	35				
Eucalyptus camaldulensis	E						1	30	30	
E. grandis	E		A							
E. maidenii	N		A							
E. tereticornis	E		A							
Glircidia sepium	N		A	9						
Pinus maximinoi	E		A	6						
Pinus patula	E		A	13						
Pinus wallichiana	N		A							

Note: N= Native, E= Exotic, A= Abandoned.

Domestication of fodder, fruit, timber and fuel-wood trees and growing them in marginal agricultural land has been practiced by farmers using their indigenous knowledge. The trees grown in farmland are not only preserving the genetic resources but also are a good source of

quality seed. TISC has identified and registered many tree species growing in the farmland as a source of seed. TISC has also carried out progeny trial for *Dalbergia sissoo.*

4.2.4 Main improvement objective (timber, pulpwood, fuel-wood, non-wood forest products)

To address the people's diverse forest products requirement, tree improvement for the tree species has been aimed accordingly. Improvement of *Dalbergia sissoo, Albizia lebbeck, Michelia champaca* and *Tectona grandis* has been aimed to improve their timber quality and quantity. On the other hand, species such as *Artocarpus lakoocha, Bauhinia purpurea, Dalbergia sissoo, Gmelina arborea, Leucaena leucocephala* are aimed to improve for their multipurpose use. *Hippophae salicifolia* and *Pterocarpus marsupium* are aimed to improve timber quality because their timber is used for medicinal purpose. Table 4.3 illustrates the improvement objectives for various other species which are managed under tree improvement programme.

Table 4.3 Tree improvement programmes

Species		Improvement programme objective					
Scientific name	Types	Timber	Pulpwood	Energy	MP	NWFP	Other
Albizia lebbeck	N	√	-	-	-	-	Fodder
Anthocephalus cadamba	N	-	-	-	-	√	Veneer, plywood
Artocarpus lakoocha	N	-	-	-	√	√	Fodder
Azadirachta indica	N	-	-	-	-	√	Medical, cosmetics, pest control
Bassia butyracea	N	-	-	-	-	√	Fruit
Bauhinia purpurea	N	-	-	-	√	√	Fodder
Bauhinia variegata	N	-	-	-	-	√	Inflorescence, pickle
Bombax ceiba	N	-	-	-	-	√	Plywood, Matchstick
Cassia fistula	N	-	-	-	-	√	Medicine, ornamental
Choerospondias axillaris	N	-	-	-	-	√	Fruit
Cinnamomum tamala	N	-	-	-	-	√	Leaf and bark used as spices
Dalbergia latifolia	N	√	-	-	-	-	Premium furniture
Dalbergia sissoo	N	√	-	-	√	-	Furniture
Ficus semicordata	N	-	-	-	√	-	Fodder
Gmelina arborea	N	√	-	-	√	-	Furniture

Hippophae salicifolia	N	-	-	-	-	√	Fruit for juice, traditional medicine
Artocarpus species	N	√	-	-	-	-	
Leucaena leucocephala	E	-	-	-	√	-	Fodder
Madhuca indica	N	-	-	-	-	√	Soap, Medicine
Michelia champaca	N	√	-	-	-	-	Furniture
Phyllanthus emblica	N	-	-	-	-	√	Fruit
Pterocarpus marsupium	N	-	-	-	-	√	Ayurvedic medicine
Tamarandus indica	N	-	-	-	-	√	Fruit
Tectona grandis	N	√	-	-	-	-	Furniture

Note; MP= Multipurpose tree improvement program, NWFP= Non-wood forest product, N=Native, E=Exotic.

4.2.5 Community involvement in tree improvement programs

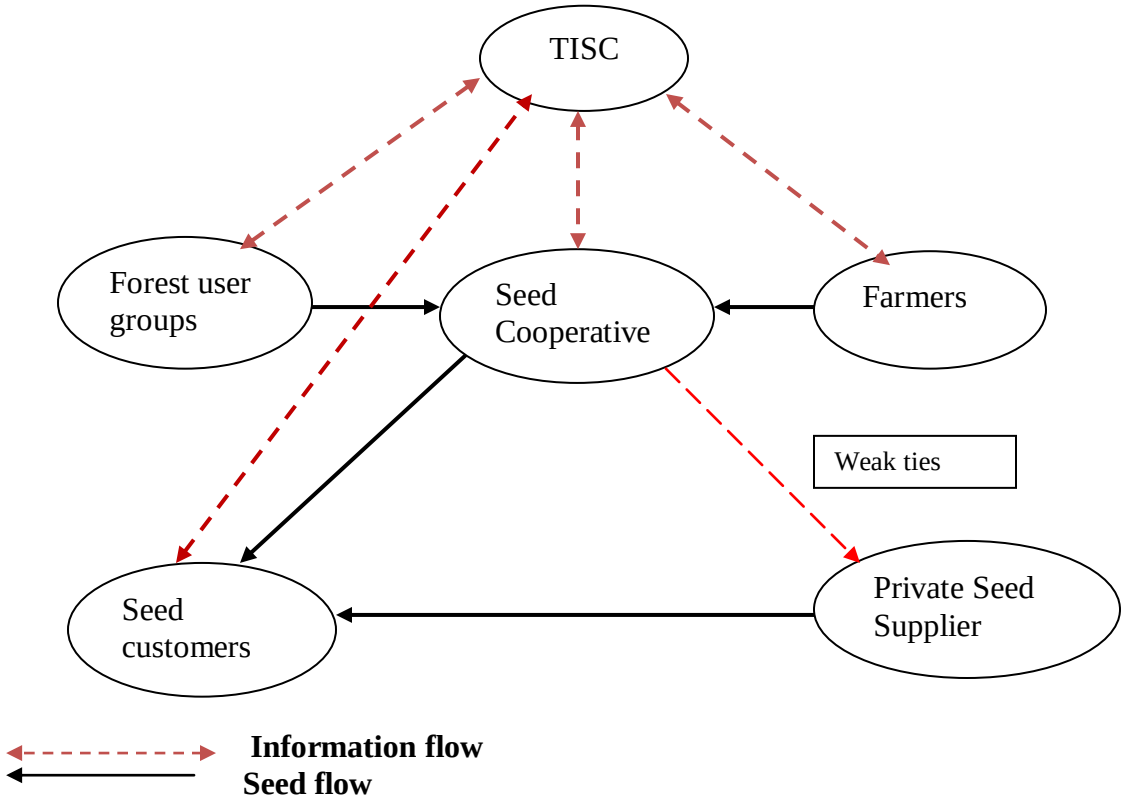
It is important to note that the local people are involved actively in the management of tree improvement programs. Various BSOs, seed stands and tree improvement trial plots are managed by the community forest user groups. Community members are involved in the entire activities from the identification of the site to the utilization of the benefits from the tree improvement programs. For example, BSOs of *Anthocephalus cadamba* and *Gmelina arborea* have been lying in the community forests. Likewise, TISC record indicates that 12 seed stands have been managed by community forest user groups, and they have been doing all the activities related to their management and TISC provides only technical assistance. According to the Forest Act 1993, all sorts of benefit from CF management including those derived from the management of tree improvement programmes goes to concerned CFUG. It is widely accepted that the tree improvement programs having community involvement are more successful and cost effective than which come under the jurisdiction of DFOs (Dhakal et al., 2005).

Besides CFUGs, many individual farmers also have been involved in tree improvement programs. A large number of tree species are maintained in farms as a part of subsistence farming systems and these species are scarce in natural forests (TISC, 2001). The trees are the main source of fodder for live-stock, which in turn provides food products such as milk and meat, and maintains soil productivity through compost and manure (Acharya, 2006). These tree species are identified as a good quality seed source. To this end, TISC has identified and registered various trees on farmland as the seed source. TISC has been providing all the technical help for the management. In addition, TISC facilitates to link individual farmer to the network of Seed Cooperatives. Individual farmer is the sole recipients of the benefits from the seed source (TISC, 2001).

4.3 Reproductive material delivery systems

Nepal has adopted a decentralised seed production and supply system, in which seeds are produced and supplied through the local cooperatives. This system is considered a novel approach in Nepal. Five seed cooperatives have been formed representing each development region of the country. They are mainly formed to make quality and cost effective seed supply. Seed cooperatives give priority to the seed supply which is in their planting zone. Figure 4.2 illustrates the current seed distribution practice in the country.

Figure 4.2 Current practice of tree seed distribution



In the early stages of cooperative formation, TISC supported seed cooperatives to establish a network of seed sources. Besides, TISC supported establishment, registration and certification of seed sources. Currently, five cooperatives and many private tree and grass seed suppliers are engaged in seed transaction. The cooperatives collect the seeds from the seed stands which TISC has been supporting in technical aspects. TISC also procures seeds from seed cooperatives and distribute them among the individual seed consumers at a nominal scale. This distribution is basically aimed more towards increasing awareness. It has been observed that occasionally private seed suppliers also buy seed from seeds cooperatives. However, this link between private seed suppliers and seed cooperatives is relatively weak.

Many studies carried out by TISC has revealed that the main problem with the present seed production in Nepal is that very few species are available in the nurseries and the genetic quality of seeds used by nurseries is not completely considered. Seed cooperatives are also facing many problems. The one pressing problem is the competition with other private tree and grass seed suppliers who usually import seeds from India at a cheap price without any documentation of genetic quality and sell it to the customers who are usually unaware about the consequences of inferior seeds. To address this problem, more effective networking, marketing of species and awareness raising is required.

4.3.1 Availability of reproductive material

An adequate supply of forest reproductive materials is a key factor for sustainable forestry. However, in Nepal seed is the main reproductive material which can be made available easily. Five seed cooperatives and private seed suppliers supply seed demand of the country. Besides, seeds are also brought from India, but this amount is not so significant. In recent years, tissue culture is also getting popular among the consumers, but mass production and distribution has not been done as yet because of lack of resources. Table 4.4 shows the list of the species seeds of which can available at present. Seeds of many of them are available at commercial scale.

Table 4.4 Type of reproductive material available

Species	Type of material	Available for national requests		Available for international requests	
		Commercial	Research	Commercial	Research
Acacia catechu	Seed	√	√	-	√
Aegle marmelos	Seed	√	√	-	√
Albizia lebbeck	Seed	√	√	-	√
Alnus nepalensis	Seed	√	√	-	√
Anthoccephalus cadamba	Seed	√	√	-	√
Artocarpus lakoocha	Seed	√	√	√	√
Azadirachta indica	Seed	√	√	-	√
Bambusa spp.	Seed	√	√	-	√
Bauhinia purpurea	Seed	√	√	√	√
Bauhinia variegata	Seed	√	√	√	√
Bombax ceiba	Seed	√	√	-	√
Callistemon viminalis	Seed	√	√	-	√
Cassia fistula	Seed	√	√	-	√
Cinamomum camphora	Seed	√	√	-	√
Cinnamomum tamala	Seed	√	√	√	√

Choerospondias axillaris	Seed	√	√	√	√
Cupressus torulosa	Seed	√	√	-	√
Dalbergia sissoo	Seed	√	√	√	√
Dalbergia latifolia	Seed	√	√	-	√
Delonix regia	Seed	√	√	√	√
Dendrocalamus spp.	Seed	√	√	-	√
Elaeocarpus sphaericus	Seed	√	√	√	√
Eucalytpus camaldulensis	Seed	√	√	-	√
Ficus semicordata	Seed	√	√	-	√
Ficus auriculata	Seed	√	√	-	√
Ficus hispida	Seed	√	√	-	√
Ficus nemoralis	Seed	√	√	-	√
Fraxinus floribunda	Seed	√	√	-	√
Jacaranda mimosifolia	Seed	√	√	-	√
Leucaena diversifolia	Seed	√	√	-	√
Lucaena leucocephala	Seed	√	√	√	√
Mallotus philippinensis	Seed	√	√	-	√
Melia azederach	Seed	√	√	√	√
Michelia champaca	Seed	√	√	√	√
Emblica officinalis	Seed	√	√	-	√
Pinus roxburghii	Seed	√	√	√	√
Pinus wallichiana	Seed	√	√	√	√
Pinus patula	Seed	√	√	-	√
Polyalthea longifolia	Seed	√	√	-	√
Prunus cerasoides	Seed	√	√	-	√
Pterocarpus marsupium	Seed	√	√	-	√
Schima wallichii	Seed	√	√	-	√
Sapindus mukorossi	Seed	√	√	√	√
Tectona grandis	Seed	√	√	√	√
Terminalia belerica	Seed	√	√	√	√
Terminalia chebula	Seed	√	√	-	√

The tree improvement programme of Nepal is not only supplying the domestic demand of seeds, but it has been delivering seeds of some species to other countries. For example, *Dalbergia sissoo* and *Prunus cerasoides* seeds were sent to Japan and Bangladesh for research purposes (see Table 4.5).

Table 4.5 Seed and vegetative propagules transferred internationally per annum (average of last 5 years)

Species	Quantity of seed (Kg)		Number of vegetative propagules		Number of saplings		Purpose
	Import	Export	Import	Export	Import	Export	
Dalbergia sissoo	-	500	-	-	-	-	Establishment of BSO in Bangladesh
Prunus cerasoides	-	19	-	-	-	-	

Source: TISC (2011)

4.3.2 National seed improvement programme

Generally choice of the species became the first planters' priority; however, a good match of planting materials to planting site can improve the benefit that the farmers obtain by growing the tree. The correct choice of seeds could make significant difference in benefits from the plantation. The use of the most appropriate seed source compared with a more or less random source may easily increase the value production. Hence, in order to enhance the benefits and reduce the risk of failure from plantation, quality seed supply is essential. There is as such no seed improvement programme in the country. Nevertheless, planting zone approach has been used to minimize the risk of failure of seeds and increase production (Lillesø et al., 2001). According to planting zone approach, ecological zones have been identified and seeds collected from a specific zone are planted within that particular ecological zone only. The seeds are distributed across other planting zones only if the field trial shows positive performance.

Study on out crossing of the many important species is lacking except for *Dalbergia sissoo* (Aryal, 1996). The study is essential to enhance the quality of plantation (Dhakal et al., 2003). For example, based on the out crossing rate of a species culling out the seedlings at the nursery could be carried out to improve the quality of plantations. Upgrading of existing seed production areas through management is also essential. Upgrading may include the selection of candidate trees or plus trees.

Currently, Seed Act 1988 also governs the transaction of forestry related seeds and Agriculture Development Ministry is the sole responsible for the controlling quality in import and export of forest seed. It is observed that Agriculture Department is more focused on the agriculture seed and could not pay adequate attention to the transaction of forest tree seeds. In addition, quality control could not be maintained because of limited knowledge with agriculture department regrading forest tree seeds. Hence, separate forest seed control act and protocol is desirable.

Chapter 5
The State of National Programmes, Research, Education, Training and Legislation

5.1 Introduction

In order to protect and sustain the use of genetic resources effective programs are essential. The Convention on Biological Diversity (1992) also urges to its parties to develop policies, strategies, plans and programs supporting genetic conservation. To this end, Nepal has developed various policies, strategies, legislation and programs. The development of good policies, plans and programs, research, education and training related to forest genetic resources is a vital to make their implementation effective.

Considering the importance of policies, strategies, plans and programs, this section describes the state of national capacities in research, education, training and legislation as well as the coordination and information mechanisms that exist for the conservation of forest genetic resources. Besides, this Chapter indicates on the gaps in policy and programs and identifies the appropriate level of intervention- national, regional and global.

5.2 National Programmes

5.2.1 Institutions involved in FGR conservation and research

Various institutions are involved in the conservation of forest genetic resources. Institutions such as DoF, DNPWC, DPR and DFRS have been engaged in carrying out research and implementing FGR conservation at the field level. DPR is equipped with laboratory for tissue culture and other phytochemical studies. In addition, various academic institutions viz. Central Department of Botany, Tribhuwan University; Department of Biotechnology, Kathmandu University run forest genetic resource related academic courses and are equipped with laboratory facilities. More than other the Central Department of Botany has a herbarium which holds about 22,000 specimens (Central Department of Botany, 2010). The Nepal Academy of Science and Technology which is mainly responsible to promote science and technology in the country is also equipped with laboratory facilities. NAST conducts research related to agricultural as well as forest genetic resources. Currently, NAST has been analysing the genotype of economically important plant species such as *Taxus wallichiana*.

Agencies such as IUCN and WWF as well as local NGOs such as the National Trust for Nature Conservation are directly involved in forest genetic conservation. Many community-based organisations along with over 1,7000 community forest user groups participate in the

conservation of natural resources through community forest management. Table 5.1 shows the list of institutions which are directly or indirectly related to forest genetic resources conservation and management in the country.

Every year the government conducts various types of programmes related to forest genetic resources. The MFSC is the line ministry which is solely responsible for policy formulation and implementing programme associated with FGR conservation. The genetic conservation programs are implemented mainly through four departments (discussed in previous chapters) under MFSC. The Educational and Research institutions also have been conducting research on forest genetic resources. However, there is no such coordination between government agencies and academic institutions regarding the priority area of research. It is also observed that research findings are generally technical in nature, and are not well communicated for use in decision-making or policy formulation (Parajuli & Pokharel, nd).

Table 5.1 Institutions involved in the conservation of FGR

SN	Name of Institutions	Type of Institution	Activities or Program	Contact information
1	Central Department of Botany, Tribhuwan University	AI	Runs academic course on Botany and carries out research related to plant resources.	Kirtipur, Kathamndu **Email:** info@cdbtu.edu.np **Website:** http://www.cdbtu.edu.np
2	Department of Forests	GO	Conservation, management and utilization of forest resources	Babar Mahal, Kathmandu, **Email:** info@dof.gov.np **Website:** http://www.dof.gov.np
3	Department of National Parks and Wildlife Conservation	GO	Manages all PAs including flora and fauna.	Babar Mahal, Kathmandu **Email:** info@dfrs.gov.np **Website:** www.dfrs.gov.np
4	Department of Plant Resources	GO	Involved in phyto-chemical, bio-chemical investigation, and mass propagation of selected plants.	Thapathali, Kathmandu **Email:** info@dnpwc.gov.np **Website:** http://www.dnpwc.gov.np
5	Institute of Forestry, Tribhuwan University	AI	Runs academic courses and carries out forestry related research.	Pokhara, Kaski **Email:** info@iof.edu.np **Website:** www.iof.edu.np
6	International Centre for Integrated Mountain Development (ICIMOD)	Inter governmental organization	Working to develop sustainable mountain ecosystem to improve the living standard of mountain populations.	Khumaltar, Lalitpur **Email:** info@icimod.org **Website:** http://www.icimod.org
7	IUCN, Nepal	UN subsidiary organization	Contributes in linking biodiversity conservation with better livelihoods.	Kupondol, Lalitpur **Email:** info-np@iucn.org **Website:** http://www.iucnnepal.org

8	Kathmandu Forestry College	AI	Runs academic courses and carries out forestry related studies.	Satdobato, Lalitpur **Email:** info@kafcol.edu.np **Website:** http://www.kafcol.edu.np
9	Kathmandu University	AI	Runs academic courses on biology and undertakes research on genetics including flora and fauna	Dhulikhel, Kavre **Email:** web@ku.edu.np **Website**: http://www.ku.edu.np/
10	Local Initiatives for Biodiversity, Research and Development (LI-BIRD)	NGO	Involved in development oriented research in Agriculture and Natural resource management.	Pokhara, Kaski **Email:** info@libird.org **Website:** http://www.libird.org/
11	National Agricultural Research Council (NARC)	Government's autonomous organization	Involved in sustainable growth of agriculture production through appropriate technologies in the different aspects of agriculture	Khumaltar, Lalitpur **Email:** ednarc@ntc.net.np **Website:** http://narc.gov.np
12	National Trust for Nature Conservation (NTNC)	National Conservation Organization	Responsible for the management of conservation areas and performs research related to flora and fauna.	Khumaltar, Lalitpur **Email:** info@ntnc.org.np **Website:** http://www.ntnc.org.np
13	Nepal Agro- forestry Seed Cooperative	NGO	Collects quality seeds from the existing seed stands and supply to domestic and international consumers.	Satdobato, Kathmandu **Email**: nart_2065@yahoo.com **Website:** http://nafnepal.org.np
14	Nepal Academy of Science and Technology (NAST)	GO	Responsible to carry out laboratory test related to FGR	Khumaltar, Lalitpur **Email:** info@nast.org.np **Website:** http://www.nast.org.np
15	UNDP, Nepal	UN subsidiary organization	Engaged in mitigating and reducing the impact of environmental degradation and biodiversity loss.	UN House, Lalitpur **Email:** dinesh.karki@undp.org **Website:** http://www.undp.org.np/
16	WWF, Nepal	INGO	Contributes in conservation and utilization of flora and fauna resources.	Baluwatar, Kathamndu **Email:** info@wwfnepal.org **Website:** http://wwfnepal.org

Note; GO=Government orgnization, NGO=Non-governmental oranization, INGO=International non-governmental organization, ML=Multilateral agency, AI= Academic Institution.

5.2.2 Legal framework for forest genetic resources strategies, plans and programmes

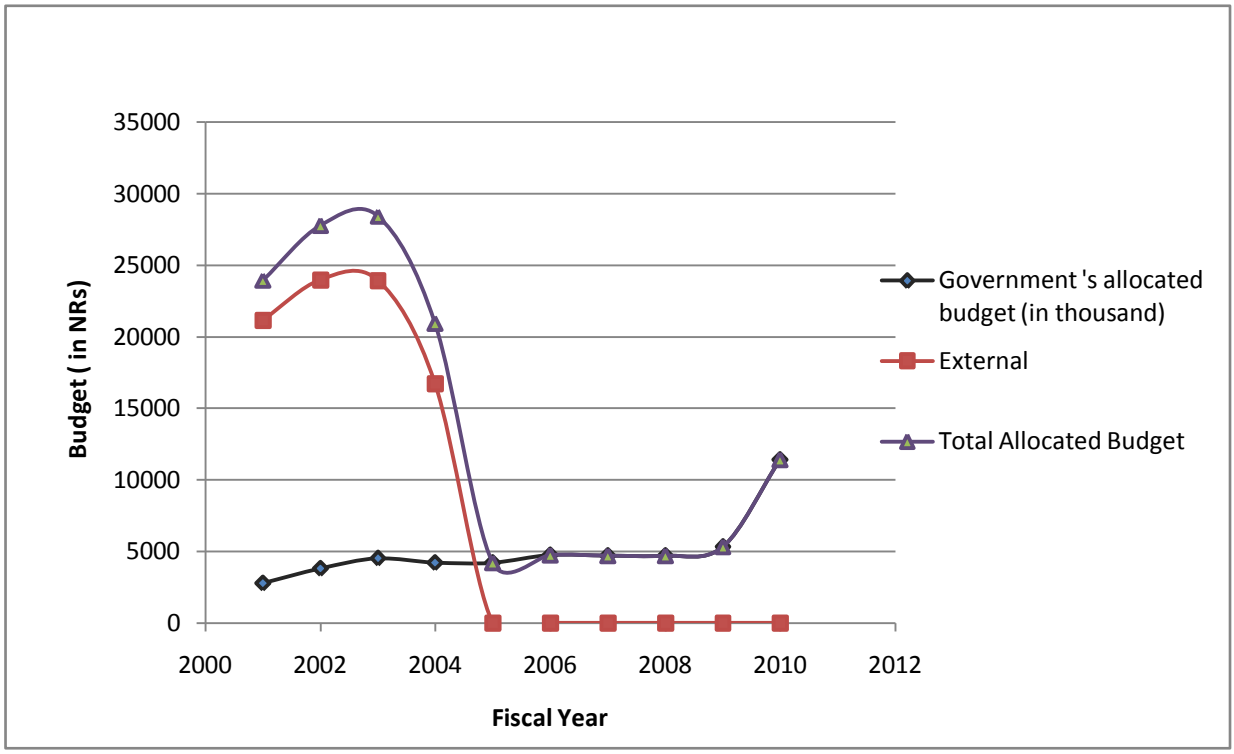
The Forest Act 1993, Forest Regulation, 1995 and National Parks and Wildlife Conservation (NPWC) Act, 1973 are three most important legal instruments to regulate the FGR of the country. Article 12 of the Forest Regulation, 1995 has provision for prohibiting collection, sale and distribution of any forest product. Under this article the government is empowered to put a ban on the collection of forest trees which are likely to be threatened or are significant for any other reasons. Besides, Article 23 of the Forest Act, 1993 has provision for protected forest. According to the article, if the government considers that any part of a national forest is of special environmental, scientific or cultural importance or of any other special importance, it may declare such part of the National Forest as a Protected Forest. The government can limit the use of forest products from the protected forest. Likewise, NPWCA (1973) has provision to declare any forest area as a protected area if the area is ecologically important in terms of flora and fauna. Considering the provisions in the Forest and NPWC Acts, the government prepares strategies, programs and activities for conservation of FGR.

The national Tree Improvement and Silviculture Programme works in cooperation with other national programmes in related areas. One of the areas is agriculture, and import or export of forest tree seed even has to go through phytosanitary screening. The Seed Quality Control Centre and National Plant Quarantine programme both under the Ministry of Agriculture Development oversee the phytosanitary screening of seed irrespective of whether it is agricultural seed or forest tree seed (Shrestha & Wulff, 2007). In many instances, forest genetic programme has to follow Environment Act, 1997 and Rules, 1997. For example, if an area of monoculture plantation is more than 50 hectare and whether it is for genetic conservation or commercial purposes it requires Initial Environmental Examination.

5.2.3 Trends in support for forest genetic resources related programme

Although invenstment in protected area management is significant and has been increasing consistently, investment specifically in FGR varied. The support for FGR has considerably changed over last 10 years and the size of support has been largely determined by external funding from the international organizations. For example, support for the TISC has been varied significantly over the last 10 years. TISC is the major government component for implementing FGR conservation. TISC received funding from Danida for its programme until 2004. Onward 2004, the government has been bearing the cost of genetic improvement programmme. Figure 5.1 demonstrates the budget allocation trends for forest genetic resources. Total budget allocation which includes both external grant and government fund seems slightly increasing over the last ten years except for the year 2010. However, the budget allocation from government side is almost invariable over the last 10 years. The government's budget for the year 2010 was noticeably high.

Figure 5.1 Budget allocation for Forest Genetic Resources over the last 10 years



The financial support received so far has been largely spent on tree improvement programme. However, the program has not been adequately effective in the absence of detail information on current status of tree species, particularly threatened, rare and endangered. In addition, the identification of the forest ecosystem type of the country seems inadequate, and lack of such information is hindering effective forest genetic conservation programme. Thus, some investment is necessary for these kinds of studies. Also, the country has some institutional and human resources constraints. There is no such permanent specialized division or section, which oversees the FGR conservation. TISC has been working on FGR conservation, but this component is of a temporary type and is not funded sufficiently. Human resources having expertise on forest genetics is not adequate; hence more expertise on forest genetics is desirable.

5.3 Networks

There is a network among the government's departments working for forest genetic resources; however, it is loosely developed. Likewise, many academic and non academic institutions have been working for the conservation of FGR in the country (See Table 5.1), but sharing of information among them only happens occasionally. So, it is essential to develop a functional network working for forest genetic resources.

5.4 Education, Research and Training

Various institutions including governmental, public and private have been involved in forest genetic resources. Table 5.2 shows the list of institutions involved. The majority of the institutions are governmental. Only a few private institutions are engaged in forest genetic resources. Most of the universities offer courses on forest genetic resources and carry out related research work. Tribhuwan University and its campuses in various parts of country including Central Department of Botany offer courses related to forest genetics. Kathmandu University which is a private university has a department of biotechnology and offers undergraduate and post graduate courses on FGR. Likewise, Institute of forestry in its two campuses offers courses on FGR.

Table 5.2 Research institutions involved in forest genetic resources

SN	Name of institutions	Category
1	Central Department of Botany, Tribhuwan university	Quasi-Governmental
2	Department of Forest Research and Survey	Governmental
3	Department of Forests	Governmental
4	Department of Plant Resources	Governmental
5	Institute of Forestry, Tribhuvan University	Governmental
6	Kathmandu Forestry College	Private
7	Kathmandu University	Private
8	Local Initiatives for Biodiversity, Research and Development (LIBIRD)	Public
9	National Agricultural Research Council	Governmental
10	National Trust for Nature Conservation	Public
11	Nepal Academy of Science and Technology	Governmental

Despite these research initiatives, the FGR themes are not sufficiently addressed in the educational curriculum among institutions of higher learning. Especially, the institutions are lacking updated technology and courses. In order to improve the country's capacity to deal with FGR issues, there is a need for an increased emphasis and more articulated teaching of these courses especially at the university level. Training facilities for seed science and technology, tree breeding, forest genetic resources conservation and other related courses deserve urgent improvement in order to keep up with technological development in these fields. Priorities for training have been identified in areas of biosafety regulations and guidelines, molecular diversity analysis, monitoring and use of genetic materials and natural resources management.

Various domestic and international organizations occasionally organize training outside the country; however, it is not sufficient. Insufficient government's resource is the main impediment for participating in education and training opportunities outside the country.

5.5 National Legislation

Forest genetic resource conservation has been guided by a series of policies over the last ten years. The government has formulated and enacted various plans, policies, strategy and laws associated with FGR conservation. These are discussed briefly in the following paragraphs.

5.5.1 Strategies, Policies and Plans related to FGR

National Bio-safety Policy (2007)
National biosafety policy has been formulated with the objective of ensuring biodiversity conservation, and human health from the adverse effect of research and development activities of modern biotechnology.

Nepal Biodiversity Strategy Implementation Plan (2006-2010)
The Nepal Biodiversity Strategy Implementation Plan (NBSIP) is a framework to materialize the vision of the NBS into practical actions for effective conservation of biodiversity and sustainable use of biological resources. Largely, the goal of the NBSIP is to contribute towards achieving the objectives set by NBS for conservation of biodiversity resources of the country including flora as well as fauna.

Master Plan for Forestry Sector (MPFS) (1989-2010)
The MPFS is the most prominent policy which guides the overall management of forest resources of the country. MPFS emphasised the conservation of forest genetic resources along with the supply of basic needs of forest products such as timber, fuel-wood and fodder.

Bio-safety Guidelines (2005)
The biosafety guideline was framed by the MFSC in 2005. The guideline aim at balancing biodiversity conservation and public health related concern with the biotechnology development in the country. The guideline has specifically paid attention on the effect of genetically modified organisms. The guideline has set up step by step provision for releasing any genetically modified organism, to make sure that it will have no adverse effect likely on human health and the environment.

Tarai Arc Landscape Strategy Plan (2004-2014)
Tarai Arc Landscape Strategy Plan emphasized landscape level planning and treats conservation as a major strategy directed for biodiversity conservation in Nepal. The strategy intended that management at the landscape level could address the two objectives of sustainable development and poverty reduction.

Nepal Biodiversity Strategy (2002)

As a signatory to the Convention on Biological Diversity at the Earth Summit (1992), Nepal has developed a Biodiversity Strategy in 2002 to meet the obligations of the Convention and to serve as an overall framework for the conservation and sustainable use of its rich biodiversity and biological resources. NBS is the commitment by Nepalese government and people of Nepal for the protection and wise use of the diverse biological resources of the country. NBS is intended to serve as a guide to all government organisations, the private sectors and civil society for the protection of biological diversity of the country.

Revised Forest Sector Policy (2000)

This forest policy provides opportunities for managing the forests of the Tarai, Inner Tarai and Churia regions of the country. The policy largely emphasises on the supply of forest products viz. Timber, fuel-wood, fodder along with conservation of ecosystems and genetic resources.

Nepal Environmental Policy and Action Plan (NEPAP), 1993

NEPAP was formulated in 1993 as a further improvement in the NCS. The plan represents the government's commitment to integrate environmental concerns with development objectives, to address the environmental problem. Specifically, the plan highlights on the need of management of natural resources based on the long term land use planning and ecological zone concept. The plan emphasized to increase on community participation in forest management through forestry research and extension.

National Conservation Strategy (NCS), 1988

The National Conservation Strategy was prepared in 1988 responding to the global World Conservation Strategy adopted in 1980. The NCS viewed the natural environmental system in a holistic way and emphasized on the wise use, protection and preservation and restoration of natural resources.

5.5.2 Legislations related to FGR

Plant Protection Act (2007) and Rules (2010)

These legal instruments regulate the introduction, establishment, prevalence and spread of pests while importing and exporting plant products. These instruments were enacted largely for agriculture products, however, are equally applied to the forest products. These legal instruments facilitate to maintain the sanitation standard of plant and plant products which are to be exported and imported. According to the rules a person or body wishing to import plants, plant products, biological control agents, beneficial organisms or means of growing plants such as soil, moss and pit should possess the entry permit. In addition, a person or body wishing to export plant products, biological control agents or beneficial organisms needs a phytosanitary certificate.

The Interim Constitution of Nepal, 2007

The Interim Constitution of Nepal, 2007 envisaged people as the source of power through decentralisation. Article 35(5) of the constitution emphasised on the protection of environment

and on the prevention of degradation due to physical development activities by increasing the awareness of the general public about the environmental cleanness. In addition, the constitution points out for the arrangements needed for the special protection of rare wildlife, the forest and vegetation.

Forest Act, 1993, Forest Regulation, 1995

The Forest Act, 1993 is the main act to regulate the forest resources of the country. The act has provisioned the protection of forest resources for meeting the forest product needs of the people. The act has provision to protect the forest genetic resources from further degradation.

National Parks and Wildlife Conservation Act, 1973

National Parks and Wildlife Conservation Act is the principal legal instrument to regulate management of Nepal's protected area system. The Act facilitates to regulate both flora and fauna lying within the protected areas. The Act strictly prohibits all kinds of destruction, exploitation and removal of fauna and flora and any damage to habitat. The Act has been revised five times to address the emerging issues. The Fifth Amendment in 2005 accommodated for the provision of handing over management responsibility for the protected areas to organizations established under the Act. The Act also highlights on the community involvement in protected area management.

5.5.3 Treaties, agreements, and conventions related to FGR conservation and management

Nepal has signed and ratified various treaties, agreements and conventions associated with the conservation of forest genetic resources. The most important ones are Convention on Biological Diversity (CBD), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and The International Plant Protection Convention (IPPC).

Convention on Biological Diversity (CBD)

Nepal is a signatory to the Convention on Biological Diversity. The major focus of the Convention is on the need for conservation to biological species, sustainable use of its components, and the fair and equitable sharing of the benefits. To this end, Nepal has given utmost importance for *in situ* conservation of biological species through the establishment of protected areas in representative ecological zones. *Ex situ* conservation is ensured by establishing Zoo and botanical gardens. In addition, as a commitment to this convention, the country has developed Biodiversity Strategy (2002) and Nepal Biodiversity Strategy Implementation Plan (2006-2010). MFSC has been serving as the focal point for the implementation of CBD.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

This convention seeks international cooperation to protect listed wildlife species from threats of over-exploitation, including their trade. Nepal as a signatory of the convention has obligation to control the trade of flora and fauna that are protected. These Conventions as well as national legislation prohibit or limit trade in endangered and rare species, their parts or products within

and outside the country. To regulate the illegal trade of flora, the government has formed special CITES section under DoF.

The International Plant Protection Convention (IPPC)
It is a multilateral treaty for plant protection involving 173 member countries. The purpose of the IPPC is to secure a common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote measures for their control.

The International Treaty on Plant Genetic Resources for Food and Agriculture
Nepal ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) on 2nd January, 2007. The Ministry of Agriculture and Cooperatives has been working as the focal point for the ITPGRFA. The treaty highlights on the sustainable conservation, use and benefit sharing of plant genetic resources.

5.5.4 Obstacles to develop legislation and regulations relevant to FGR

There are a number of obstacles in respet to developing legislation and regulation relevant to forest genetic resources. First is the lack of information. The country lacks a comprehensive assessment of forest genetic resources. In the absence of precise information, it is difficult to design informed policy measures. An effective example is the status of threatened species; the country is following CITES list of protected flora and fauna, which has remained unchanged since 1973 due to the absence of proper assessment. Second is the complexity in matching with international treaties and agreements in national context. To address this mismatch, regular multi-stakeholders' consultation on diverse issues related to conservation and sustainable use of FGR will help develop legislations that take account of national interests in response to international commitments. Table 5.3 indicates the needs of the country and their respective priority levels.

Table 5.3 Needs for developing forest genetic resources legislation

Needs	Priority level			
	Not applicable	**Low**	**Moderate**	**High**
Improve forest genetic resources legislation				√
Improve reporting requirements				√
Consider sanction for non-compliance			√	
Create forest genetic resources targeted regulations			√	
Improve effectiveness of forest genetic resources regulations			√	
Enhance cooperation between forest genetic resources national authorities				√
Create a permanent national commission for conservation and management of forest genetic resources			√	

5.6 Information Systems

National Information Management Systems have not been developed to support efforts to sustainably use, develop and conserve FGR owing to lack of resources. International support is needed to establish national information management system in terms of human resources and infrastructure development. Many organisations viz. the Mountain Institute 1993–1994, Biodiversity Profile Project in 1995, International Legume Database Information System in 1995, Central Department of Botany, TU 1998–1999, have been involved in management of databases related to conservation, utilization and monitoring of biodiversity resources. However, coordination and linkages among the organizations have not been developed strongly.

5.7 Public Awareness

It has been observed that public awareness on the roles and values of forest genetic resources is not at the satisfactory level. Involvement of governmental and non-governmental organisations in multiple forums such as mass media (radio, television), workshops, seminars, publications, exhibitions have contributed to create awareness among the people (NBS, 2002). However, there is a lack of awareness on strategy, particularly, for forest genetic resources. Access to mass media such as internet and television has not been widely extended in rural areas of the country. As a result, the people living in the rural areas are not much aware about the significance of forest genetic resources. Table 5.4 shows some awareness raising needs of the country and their priority level.

Table 5.4 Level of awareness

Needs	Priority level			
	Not applicable	Low	Moderate	High
Prepare targeted forest genetic resources information			√	
Prepare targeted forest genetic resources communication strategy			√	
Improve access to forest genetic resources information				√
Enhance forest genetic resources training and education				√
Improve understanding of benefits and values of forest genetic resources				√

Chapter 6

The State of Regional and International Collaboration

6.1 Introduction

It is evident that all the countries of the world are interdependent in terms of FGR. This interdependency calls for cooperation and collaboration at the regional and international level. To this end, Nepal has maintained linkage with various regional and international agencies, relevant to the conservation and management of FGR. These collaborative efforts are expected to have great help in improving the country's capacity in conservation and sustainable management of FGR.

Taking into account the needs of collaboration with regional and international agencies this Chapter examines the level of network, fora and other mechanism for promoting and supporting collaboration. Also, the Chapter explains on the international funding mechanisms that have continually supported the country in the various FGR related activities. An assessment of the major needs, gaps and priorities is also discussed in this Chapter.

6.2 International Networks

Nepal has been a participant of various regional, sub-regional forest genetic resources network. Table 6.1 provides details of various network of which Nepal has been a participant. The prominent ones are *The Internal Neem Network International* (INNI), *Network on Bamboo and Rattan* in promotion of conservation and sustainable use of forest genetic resources of the country. As a participant of the INNI, Nepal has been sharing knowledge, experience, information on genetic resources related to Neem *(Azadirachta indica)*. In addition, Nepal has provided space to undertake provenance trail for Neem**.**

Table 6.1 Overview of the main activities carried out through networks and their outputs

Network name	Activities	Genus/species involved
Asia Pacific Association of Forest Research Institutions (APAFRI)	Enhances research and technology development capabilities in support of conservation and management of forest resources in the Asia-Pacific region.	General
Asia Pacific Forest Genetic Resource Programme (APFORGEN)	Involves in conservation and sustainable use of tropical forest genetic resources in Asia and Pacific region.	General
Convention on Biological Diversity (CBD)	Conservation, sustainable use and fair and equitable sharing of the benefits arising out of biological	General

	diversity.	
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	It aims to protect endangered wild flora and fauna by restricting their international trade.	General
Diversity International	Research for development to investigate the conservation and use of plant biodiversity	General
ICIMOD	Carry out research and development on biodiversity conservation and its sustainable use	General
Improved Productivity of Man-Made Forests through Application of Technological Advances in Tree Breeding and Propagation (FORTIP)	Aimed at improving forest productivity through genetic enhancement of forest trees.	General
International Network on Bamboo and Rattan (INBAR)	Helping to develop capacity in technology and product development, propagation, provenance testing, establishment of bamboo living collections, bamboo resource inventory, preservation techniques, utilization, socio-economic studies, rehabilitation of degraded and wastelands, market research and policy development.	Bamboo species and Rattan
SAARC Forestry Center	Deals with common issues related to forest and environment conservation.	General
The International Neem Network	Improve the genetic quality and adaptability of Neem and its utilization throughout the world as contribution to development in the countries concerned, with particular focus on meeting the needs of rural people.	*Azadirachta indica* (Neem)

Although Nepal has been participating in a number of regional and sub-regional networks, the country has been able to reap very limited benefits. In some cases, networking has benefited to technology development and information sharing but these, too, have been limited. In some instances, Nepal has been participating in network programmes which are not a national priority. Hence, in those cases, success of the programme is less likely. The lack of coordination between the government and network generally creates this sort of issues. To address this issue, a realistic plan of action compatible with national priorities is essential. In addition, the government is lacking sufficient skilled human resources to participate effectively in the networks and be benefited fully. Likewise the country has not adequate conservation infrastructures to be able to receive greater benefit from the networking.

6.3 International Programmes

Many international programs have been implemented for forest genetic resources in the country. The programs that are relatively more beneficial to the country are discussed below.

FORTIP

FORTIP is the abbreviated title of the UNDP/FAO Regional Project on "Improved Productivity of Man-Made Forests through Application of Technological Advances in Tree Breeding and Propagation". It is one of the leading UNDP/FAO supported forestry programmes in the Asia and Pacific region aimed at improving forest productivity through genetic enhancement of forest tree. The first meeting of the Tree Improvement Programme together with FORTIP was first held in 1992. The meeting listed ten important forest tree species in Nepal for tree breeding and propagation research. FORTIP is the agency which first initiated Tree Improvement Programme under DFRS. The DFRS had a mandate to conduct tree breeding and propagation activity on four species *Alnus nepalensis, Eucalyptus camaldulensis, Artocarpus lakoocha* and *Pinus roxburghii*.

Danida

Danida supported forest genetic conservation activities within the Natural Resource Management Sector Assistance Programme for 15 years. The support was mainly in the establishment of Breeding Seed Orchard and Seed Stands for economically and threatened species. Also, Danida assisted in implementing decentralized seed collection distribution programme. The programme is recognized as an innovative initiative of Danida. Under this programme, four seed cooperatives were established in four development region considering seed zones. The cooperatives are still functioning. Other significant contributions of Danida are the vegetation mapping, seed zoning, and conservation area for threatened species. Danida along with tree improvement programme, initiated silvicultural component as a complementary programme.

ICIMOD

ICIMOD mainly works at the interface between research and development and acts as a facilitator for generating new mountain specific knowledge relevant to mountain development. With respect to forest genetic resources, ICIMOD has been sharing information related to forest genetic resources through the various publications. "Biodiversity Resource Book, 2007" is the recent publication on forest genetic resources. In the book, ICIMOD has attempted to list the ecosystem and forests types of Nepal. Also, ICIMOD supports the country by providing assessment of FGR at regular intervals.

APFORGEN

APFORGEN has been contributing to enhance technical and scientific cooperation, training and information exchange. In the context of Nepal, its contribution is significant in documenting and information sharing.

Although Nepal has been benefitted from many international programmes, however, no regular financial support has been realized from any international programme. The international programmes generally have been intermittent and one-off only. Because of this tendency of international programme, no substantial achievement has been realized in forest genetic resources. Danida is the only bilateral agency which supported forest genetic resource development for more than 15 years continuously.

6.3.1 Needs and priorities for future international collaboration

It is widely realised that the state of diversity in terms of species, genetic and ecosystems has not been comprehensively studied. The existing knowledge or information so far on the diversity status are briefly studied and are obsolete. Only few studies have been undertaken on diversity studies at the genetic level, using advanced molecular techniques, hence development of protocols for diversity assessment using molecular techniques for other species is desirable. At the same time, a country like Nepal cannot affords the cost of such study, hence international collaboration is essential. Collaboration with FAO through NFP or similar financial mechanism is required for the development of forest genetic resources. International collaboration in various fields such as *ex situ* and *in situ* conservation, education and training, developing legislations is also desirable (see Table 6.2).

Table 6.2 Needs for international collaboration and networking

Needs	Level of priority			
	Not applicable	Low	Medium	High
Understanding the state of diversity				√
Enhancing *in situ* management and conservation				√
Enhancing *ex situ* management and conservation				√
Enhancing use of forest genetic resources			√	
Enhancing research				√
Enhancing education and training				√
Enhancing legislation			√	
Enhancing information management and early warning systems for forest genetic resources.				√
Enhancing public awareness				√

6.3.2 *In situ* and *ex situ* conservation

At present, not all the species which are categorized as threatened or economically important have been managed under *ex situ* and *in situ* conservation. There are still numerous threatened species for which conservation strategies or funding are lacking. In addition, it has been realized that area allocated for the conservation is not sufficient to ensure their future conservation. Hence, conservation of more species and in larger area is needed. At present, the country has inadequate skilled human resources associated to FGR; hence international collaboration is essential to enhance trained human resources.

Other than forestland, farmland also contains tremendous tree diversity. It has been found that many tree species are only remained in agricultural farm, so incentive programme to the farmers is needed to ensure the conservation of the tree species (Acharya, 2006). It is widely realized that gene bank for the forest tree species is of urgent need. Establishing gene bank involves high cost and the programme needs collaborative support from international programmes.

Current management system of *in situ* conservation through protected area management is highly focused on particular fauna, and adequate attention has not been placed for ecosystems, species and genetic diversity. One reason for this tendency may be because of insufficient information related to ecosystems and species diversity in the protected areas. Hence, detail study on status of ecosystems and species within the PAs is desirable.

6.3.3 Enhancing research

- Enhanced research capability by augmenting organizations' infrastructure and human resources
- Database system for research and other information related to forest genetic resources
- Develop collaboration mechanism among the institutions involved in forest genetic resource conservation

6.3.4 Enhancing education and training

Academic courses and teaching methods are obsolete, and fail to engender the critical analytical skills needed in effective conservation of forest genetic resources. Hence, the courses in the academic institutions need revision and need to include more courses on cross cutting issues.

6.3.5 Enhancing legislation

- Harmonization of international treaties and agreements in national perspective
- Instead of the current status of distributed responsibility of forest genetic resources among the multiple departments, a single department focus mandate is needed

6.3.6 Enhancing information management and early warning systems for FGR

- Capacity building in information management and early warning system has been necessary.

Chapter 7
Access to Forest Genetics Resource and Sharing of Benefits Arising from their Use

7.1 Introduction

It is widely accepted that forest genetic resources have been degrading continuously mainly owing to anthropological pressure. The rate of degradation is relatively more in the regions where the population is highly dependent on the forest resources. This high dependency on forest and shortage of alternatives impedes the sustainability of forest management. The issue of sustainability could be addressed if the forest users are able to generate benefits from the forest resources. Many populations have not been able to capture adequate benefits from the forest genetic resources to ensure the conservation of forest genetic resources. In order to overcome shortage of forest resources, it is imperative that to create benefits to the population to search for alternative and to create ownership over forest resources. With this respect, access to forest genetic resources and equitable and fair sharing of benefits arising from the utilization of forest genetic resources is necessary.

Considering the above fact, this Chapter explains the state of access to forest genetic resources, transfer and sharing benefit arising out of their use. Further, this Chapter describes the level of intervention at national, regional and global that Nepal has adopted as related to regulation, Agreements and stakeholders.

7.2 Access to forest genetic resources

Nepal has subscribed to various international agreements relevant to access and benefit sharing from FGR. The major agreements include Convention on Biological Diversity (CBD), Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), Indigenous and Tribal Peoples Convention (C169), and Trade Related Aspect of Intellectual Property Rights (TRIPS).

7.2.1 International agreement relevant to access to and sharing of benefit from FGR

Nepal has signed the CBD on 12 June 1992, ratified it on 15 September 1993, and became a party to the convention on 21st February 1994 (MFSC, 2006). The MFSC has been serving as the national focal point for the implementation of the CBD at the national level. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources is one of the three overall objectives of the CBD along with the conservation of biodiversity and sustainable use of its components. The article 15 of the CBD states the principles and obligations of the

parties related to access to genetic resources and the fair and equitable sharing of benefits generated from the utilization of genetic resources, on the basis of prior informed consent and mutually agreed terms.

Nepal has also ratified ITPGRFA on January 2, 2007 with objective of conservation and sustainable use of plant genetic resources for food and agriculture and fair and equitable use of benefits derived from their use. Ministry of Agriculture and Cooperatives has been appointed as a focal ministry.

In addition to these two international treaties, on 14 September 2007 Nepal has ratified Indigenous and Tribal Peoples Convention (C169), in 1989 adopted by International Labour Organization (ILO). The convention safeguards the rights of the indigenous people to the natural resources pertaining to their land and ensures rights to participate in the use management and conservation of the resources (ILO, 2007). Likewise, with the aims of wider opportunities by integration into the world economy and multilateral trading system, Nepal has agreed on World Trade Organization's membership on 23 April, 2004. Nepal's commitment to the membership includes the implementation of Agreement on TRIPS.

With the objective of fair and equitable sharing of benefits arising from the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity, Nepal attended a convention for Nagoya Protocol on 29 October 2010. In this regard, Nepal has not signed the protocol yet, and only acceded to it

7.2.2 National legislation and policies providing access to FGR and sharing of benefits

As being a party of the convention, Nepal is committed to implement the CBD. To this end, legislative and policy measures on access to genetic resources have long been an issue of discussion in the country. In various policies, including the periodic national development plans (2007-2010), Nepal has expressed its commitment to the protection and management of biological diversity on a sustainable basis for the benefit of Nepal's present and future generations and for the global community as a whole.

The Nepal Biodiversity Strategy (NBS) had been approved in 2002 and its Implementation Plan in 2006. The NBS provided a framework for the conservation of biodiversity, the maintenance of ecological process and systems and equitable share of benefits derived from its use. Biodiversity Implementation Plan framework is to materialize the vision of NBS into practical action to achieve the goal of conservation sustainable utilization of biodiversity. Similarly, a bill on access to genetic resources and its regulation has been drafted and is waiting for approval. The bill has provision of access to genetic resources and sharing of benefits arising from the utilization of genetic resources. This legislation deals with rules and regulations concerning access to genetic resources and sharing of benefits arising out of the commercial use of genetic resources and associated traditional knowledge. The bill also deals with prior informed consent (PIC)

procedures and negotiations between both parties to develop mutually agreed terms (MAT) to ensure the fair and equitable sharing of genetic resources and associated benefits.

Besides these, various policies relevant to implementation of CBD have been enacted such as Herbs and Non-Timber Forest Products Policy 2004, National Wetlands Policy 2003 and Biotechnology 2006. These policies have provisioned the benefit sharing between the users and providers.

7.3 Management actions to maintain access to FGR

There is no such management action from the Nepalese government to maintain or enhance access to forest genetic resources located outside the country over last ten years.

7.4 Difficulties in maintaining or enhancing access to FGR

In the absence of ABS regulation, it is observed that the access to forest genetic resources and benefits sharing between users and providers are not as anticipated by the CBD. Contracting parties have even seen a kind of situation in which both parties do not respond to each other's enquiries concerned with access to specific plant genetic resources.

In the view of emerging concerned associated with access to forest genetic resources and benefit sharing from it, legal instruments are there to restrict the access to the forest genetic resources. For example, Forest Act 1993 and Forest Regulation 1995 can restrict the collection and utlilization of any forest products if it is essential. Currently, Forest Act has restricted collection, transportation and felling of *Michelia champaca, Acacia catechu, Bombax ceiba, Pterocarpus marsupium, Dalbergia latifolia* and *Juglans regia* (only of national forest) (GoN, 1993). The restrictions are status based and likely impact of their collection on ecosystem.

7.5 Sharing of benefits arising out of the use of FGR

7.5.1 Mechanism of benefit sharing arising out of the use of FGR

Formal events of benefit sharing between the users and providers have not been recorded. However, the ABS bill has provision of access and benefit sharing mechanism among the government, which implements the ABS law and local and indigenous communities. According to the mechanism, when government owns the resources, government receives 50 percent, authority receives 30 and local community receives remaining 20 percent. On the other hand, if community owns the resources, community receives 51 percent, authority receives 20 percent, and government receives remaining 29 percent. In addition, the bill also provisions that out of the benefits received by the owners, 20 percent of the received benefits will have to be shared with local government institution for investment in the conservation and development of biodiversity.

7.5.2 Obstacles to achieving the fair and equitable sharing of the benefits from FGR

The main obstacles in achieving fair and equitable sharing of the benefits are:

- lack of information regarding the use, value and importance of the resources,
- lack of mechanism to identify the rightful holders of genetic resources, in the absence of documentation and registration, For example multiple owners claims the same resources and associated knowledge,
- inadequate capacity at local level,
- limited institutional arrangement to facilitate the access to the resources, and
- lack of dispute settlement at the community level.

7.5.3 The importance of maintaining or enhancing access to FGR and benefit-sharing

Maintaining and enhancing access to forest genetic resources and benefit sharing is highly important for the country like Nepal, which is genetically diverse and where many indigenous groups of people reside and retains different traditional knowledge (ICIMOD, nd). Without fair and equitable benefit sharing with those indigenous groups of people conservation of forest genetic resources is less likely.

Maintenance and enhancement of access to forest genetic resources and benefit sharing requires interventions mainly at three levels; policy, institutional and practice. A strategy has to be prepared considering the national and local level issues such as with regards to creating linkages among government, private owners, community and civil society including media for wider sensitisation regarding implementation of rules and regulations related to ABS mechanism. Institutional arrangement at the national and local level is essential without the arrangement it will be complicated to maintain and enhance the access to genetic resources and benefit sharing. Finally, enhancement of capacity both at community and national levels is desirable. For example, enhancement of capacity in recording the genetic resources and associated traditional knowledge, mobilisation of fund received from the benefits sharing and negotiations for mutually agreed fund are some pressing issues which have to be resolved.

Chapter 8

The Contribution of Forest Genetic Resources to Food Security, Poverty Alleviation and Sustainable Development

8.1 Introduction

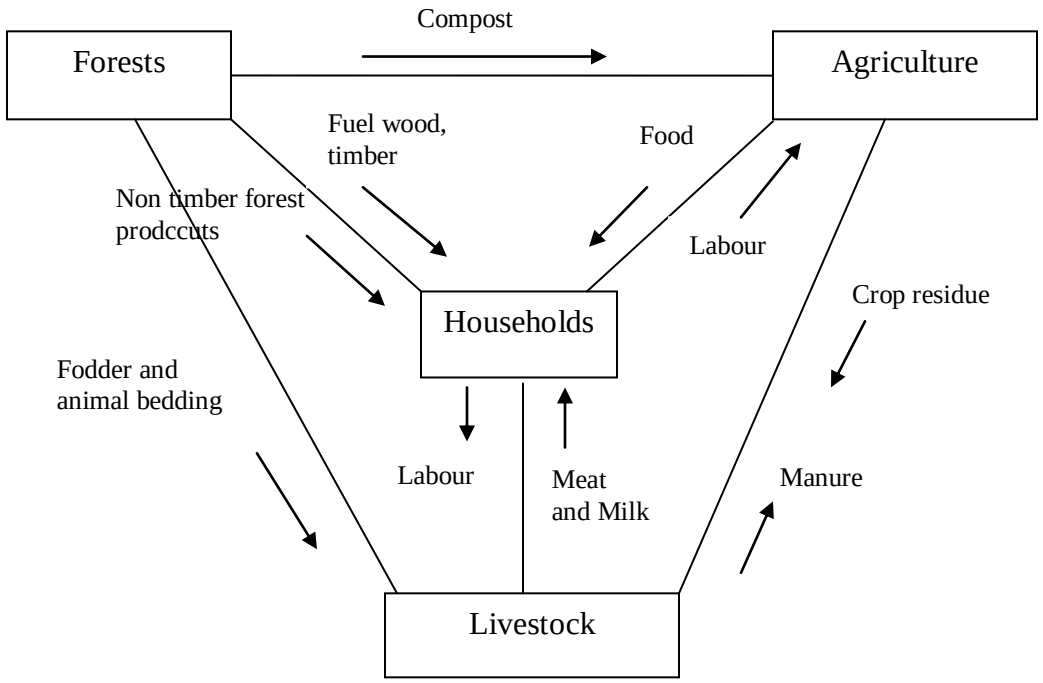
FGR has an immense potential to generate income opportunities for communities. Forest genetic diversity gives a population the ability to adapt to changing environments. For resource-poor farmers forest tree diversity creates multiple options to secure livelihoods.

This chapter highlights the status, needs and priorities of the contributions of forest genetic resources to food security, poverty alleviation and sustainable development. In addition this chapter explains the level of intervention - national, regional and/or global. Information in the following areas should be considered in developing the Country Report, the contribution of forest genetic resources to:

8.2 Forest and agricultural sustainability

Agriculture is considered a mainstay of Nepalese economy and it is a major source of livelihood (Thapa, 1996). However, agriculture is largely subsistence oriented and dominated by small farmers having average land size less than one hectare (Malla, 2000). It is estimated that about 74 percent of the total population still depends on agriculture for their subsistence (GoN, 2010). Agriculture sector contributes about one third of the GDP and it has immense role to play in reducing poverty (GoN, 2010). Sustainability in agriculture production is very important to boost Nepalese economy. On the other hand, forest resources are an integral part of agriculture systems for many farmers including livestock and providing both cash and subsistence benefits (Acharya 2006). These benefits come from the trees grown or managed on farms as well as from forest resources in communally managed and government managed forest. Figure 8.1 shows the simplified schematic model of inter linkages between forestry, agriculture and livestock in Nepal. The Figure demonstrate that forests are integrated into agricultural systems and provides range of benefits in terms of restoring or sustaining soil fertility through composting and resulting sustainable agriculture production. Forest provides fodder and animal bedding to livestock which in turn provide manure to the agriculture and meat and milk to the households.

Figure 8.1 Inter-linkage between forestry, agriculture and livestock in Nepal



Modified and Adopted from Agrawal (2000).

Rural households require diverse forest products such as fodder, fuel wood, timber and compost to sustain the agriculture production and other livelihood activities. All these requirements are not supplied unless forest species diversity is maintained. For this reason, people maintain forest species diversity in their farm land as well as in other types of forest including community managed forests (Lawrence et al., 2006).

The forest and its diverse form is the main factor to sustain the agriculture production. The desired ratio between forest and cultivated land is considered to be 1–3. Given the existing cover of the forest it is not possible to maintain the farm land and forest over ratio. In addition, plenty of case studies have shown livestock population have been increasing and deforestation is continued resulting a short supply of forest products mainly fodder and bedding material which are used as input to the agriculture production. Likewise, several studies have indicated that agriculture lands have been losing soil nutrients; this has been exacerbated further by inability of farmers using manure in absence of forest resources (Carson, 1992; Desbiez et al., 2004; Neupane & Thapa, 2001). This has been leading agriculture production either remained stagnate or decline. The continuous loss of nutrients from the farmland is serious constraints to the sustainable agriculture production. Increase in Agro-forestry practices and improvement in forest genetic resources in natural forest could be the potential strategies to sustain the agriculture production.

Farmers have historically protected, managed or planted trees on their land and increasing doing so as nearby forests recede or are degraded from overharvesting.

8.3 Climate change and environmental stability

As in the other part of the world, Nepal is also experiencing climate variation. A study showed that temperature has increased by an average 0.06^0 per year between 1977-1994 (Shrestha et al., 1999). Plenty of evidence suggests that various ecosystems have been affected by events associated with climate change. Flood disasters in low land during wet season, species extinction due to frequent forest fire, glacial lake outburst floods are some of the events associated with climate change (Huq et al., 2004; Kääb et al., 2005). The consequences of these events not only have been affecting the environment of Nepal but also the lives of huge numbers of people. In these circumstances, the forest genetic resources only impacted by climate change, FGR also plays crucial role in climate change mitigation and adaption. The appropriate use of genetic diversity provides flexibility with respect to forest management and helps to reduce the risks associated with climate change. Forest genetic diversity plays a critical role in survival of population in rapidly change climate.

It is widely accepted that forest species having local origin are more adapted to the local condition hence better cope with changing environment. However, the knowledge on the adaptability of tree species to climate change is poorly understood in the country. A study on the scale and degree of adaptability of tree species could help to mitigate the impact of climate change in larger extent. Provenance trial can explore the scale and degree of local adaption. Another way is the reciprocal transfer experiment, in which planting stock and seed are transferred between a series of sites and then performance is evaluated. In addition, a strategy is needed to deal with climate change through wise management of forest genetic resources. For example, by maintaining high genotypic diversity and encouraging natural regeneration in the forest may increase the survival rate of species, hence facilitate to cope with climate change.

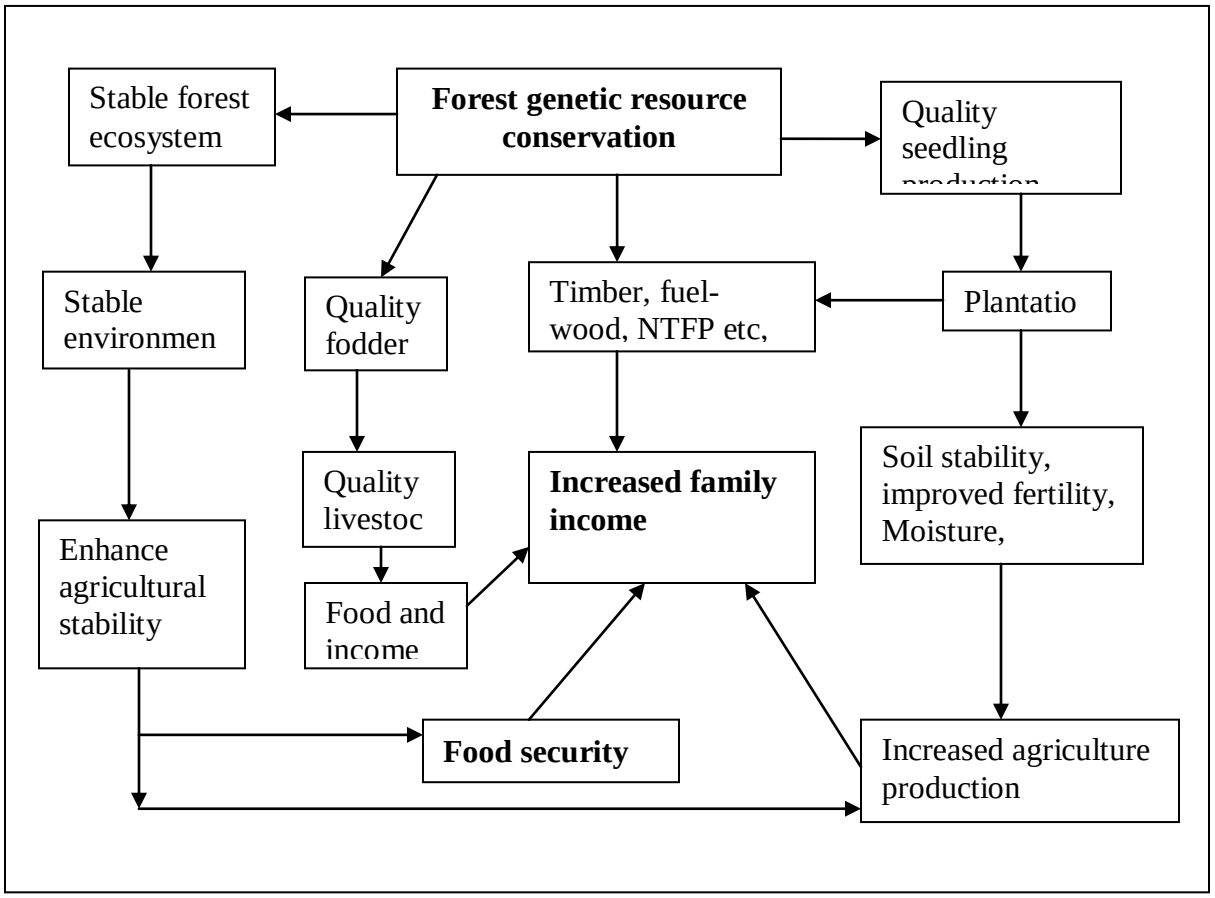
8.4 Food security and poverty alleviation

Given the huge ecological diversity, Nepal is endowed with rich forest genetic diversity. Forest genetic diversity is closely linked to food security and poverty alleviation in Nepal. About 85 percent of population reside in rural area (CBS, 2011). Even though agriculture is the main source of food and income for many rural populations, it is not able to meet annual requirement. Hence, the forest products have been a way of life to supplement the food requirements. Many species of trees laying on farms as well forest trees and associated understorey shrubs and grasses, are used as a food when other food sources are scarce. It has been estimated that 80 percent of the fodder requirements of the country is supplied from the forest trees this includes both from private forest and national forest (CBS, 2011). About 70 percent of the population of the country collects fodder for their livestock (CBS, 2011). In addition, forest tree contribute to the domestic livestock production which in turn influences milk and meat production.

As in many other developing countries, fuel wood is the main source of energy in the context of Nepal. Fuel wood supplies thus indirectly affect the stability, quality and quantity of food. Research conducted in Nepal has shown that about 64 percent of population use fuel wood for cooking. Forest supplies approximately 89 percent of the fuel wood requirement (CBS, 2011). The fuel wood shortage affects the quality of food. These data indicates the link between forest resources in food security of the country. Figure 8.2 shows the association between forest resources and food security and poverty.

It is often very poor people depend highly on the forest products (CBS, 2011). Households living on the margins of poverty are exposed to food security at certain times of the year when income levels drop (Dhakal et al., 2007). This may be during the lean season (the period when crops are growing in the fields and or in times of famine or food shortage) for these families forest provides an important safety net and it is in these critical periods that the importance of forest foods in greatest.

Figure 8.2 Linkages between forest genetic resources, food security and poverty



Source: Adopted and modified from Jha (2006).

Several studies have shown the importance of forest genetic resources in food security. In one study by Shrestha & Dhillion (2006) undertaken in *Dolkha* district have found that 62 wild

species belonging to to 36 families were edible. Of these, 39% were herbs, 37% trees, 14% shrubs, and 10 % climbers. Fruits (46%) and green leafy vegetative parts (leaves and tender shoots; 37%) were the major type of food plants found. In addition the study observed that most of the wild food plants were collected and consumed by the local communities as snacks. Some of these plants were supplementary and nutritionally important. Flowers of species such as *Rhododendron arboreum* was used for juice, pickles and snacks. Other important tree species that have been used for food included *Saurauia napaulensis, Castanopsis indica, Castanopsis tribuloides, Ficus auriculata, Ficus neriifolia, Dendrocalamus hamiltoni* and *Prunus cerasoides.*

Nepal is socially heterogeneous and many tribal communities highly depend on forest products for their livelihoods and nutritional requirement. One of them is *Chepang* community, who is still having semi-nomadic way of life. The *Chepang* community is considered highly marginalised and usually confronted with food deficit problem. A study carried out in Chitwan District by Thapa (2008) indicated that *Chepang* community remained food deficit for six months. Overall, forest products contributed 18.14 percent in the total income. Even among them poor community derived higher income than medium and rich community. *Aesandra butyracea* was the most preferred tree species in the *Chepang* community. Besides, they derived income from tree species such as *Michilus odoratissima, Caeseria esculenta, Schleichera oleosa,* and *Tamarindus indica*. Furthermore, it was found that *Chepang* community have been using 17 species including tree species for food requirement. Other than species mentioned before various types of tree species and their products have been used by the people as food resource and for poverty reduction. Table 8.1 lists the tree species used for food and poverty alleviation.

Eliminating poverty and sustaining development are highest priorities under Millennium Development Goals. Not only for food security forest genetic resources are important tools for addressing poverty issues for marginalised and forest dependent communities. Income from forests and from trees on farms has been making a significant contribution to rural households. Hundreds of species are used as non timber forest product and have great conservation and economic value for the many households. In some community, forest genetic resources provide up to 50 percent of the total income (Edwards, 1996). The use of non timber forest products however, varies from one community to other community depending on the heterogeneity and tradition practices by the ethnic group. A recent study in Bardia district indicated that non timber forest products have been significantly contributing to the livelihood of *Tharu* community. The study identified that 101 species have been used for the livelihood and income generation. The important species used included *Bauhinia variegata, Syzygium cumini, Ficus racemosa, Aegle marmelos, Schleichera oleosa, Phyllanthus emblica, Terminalia chebula, Terminalia bellirica.* Despite the fact many forest tree species have been used by various community for income generation thereby reducing poverty, the community are not able to receive the potential value of the products owing to the absence competitive market opportunities. Hence expansion of market opportunities and capacity building programmes for the local people and local institutions are essential.

Table 8.1 List the tree and other woody FGR contributes to food security and livelihoods

Species		Use for food security	Use for poverty reduction
Scientific name	**Native or exotic**		
Acacia catechu	N	√	√
Acacia nilotica	E		√
Acorus calamus	N		√
Adina cordifolia	N		√
Aegle marmelos	N	√	
Ardisia macrocarpa	N		
Artocarpus integra	N		
Azadirachta indica	N	√	√
Bassia butyracea	N	√	√
Bauhinia variegata	N	√	√
Bombax ceiba	N		√
Buchanania latifolia	N		
Cajanus cajan	N	√	
Calamus tenuis	N		√
Careya arborea	N	√	
Castanopsis indica	N		√
Castanopsis tribuloides	N		√
Choerospondias axillaris	N	√	√
Dalbergia sissoo	N		√
Dendrocalamus hamiltonii	N	√	
Desmodium oojeinense	N	√	
Diospyros melanoxylon	N		√
Elaeocarpus sphaericus	N		√
Ficus auriculata	N	√	
Ficus hispida	N	√	√
Ficus lacor	N	√	
Ficus neriifolia	N	√	
Ficus racemosa	N	√	
Grewia optiva	N	√	
Hipppophae salicifolia	N	√	
Juglans regia	N	√	
Lannea coromandelica	N		√
Madhuca longifolia	N	√	
Mangifera indica	N	√	
Morus serrata	N	√	
Myrica esculenta	N	√	
Phyllanthus emblica	N	√	

Piper longum	N	√	
Polyalthia longifolia	N	√	√
Prunus cerasoides	N	√	
Psidium guajava	N	√	
Putrajiva roxburghii	N	√	
Pyrus pashia	N	√	
Rhododendron spp.	N	√	√
Rubus ellipticus	N	√	
Sapindus mukorossi	N		√
Schleichera oleosa	N	√	√
Shorea robusta	N		√
Solanum surattense	N		√
Syzygium cumini	N	√	√
Terminalia bellirica	N	√	
Terminalia chebula	N	√	
Tinospora sinensis	N		√
Toona ciliata	N		√
Zizyphus mauritiana	N	√	

Source : Uprety et al.,(2010) and Shrestha & Dhillion (2006)

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Appendix A

List of participants involved in FGR preparation process

National Committee Member			
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3	Mr. Krishna Acharya	DG, Department of National Park and Wildlife Conservation	Member
4	Mr. Resham Bahadur Dangi	Chief, Joint Secretary REDD-Forestry and Climate Change Cell, MFSC	Member
5	Dr. Ram Prasad Chaudhary	Professor, Central Department of Botany, Tribhuwan University	Member
6	Apsara Chapagain	Chairman, Federation of Community Forest Users, Nepal	Member
Focal Point			
	Hem Lal Aryal	Under Secretary, Department of Forests	
Working Committee Member			
1	Sagar Rimal	Under Secretary, Environment Division, MFSC	Member
2	Dr. Maheshwar Dhakal	Ecologist, DNPWC	Member
3	Deepak Kharal	Under Secretary, DFRS	Member
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Appendix B

Types of Ecosystems in Nepal

SN	Ecological zones	Code	Ecosystem type
1	Nival	1000	Glacier, snow, rock
2	Alpine	2101	Alpine meadow with *Gramineae* and *Cyperaceae*
2.1	Upper alpine	2102	Xerophytic mat patches and scarcely vegetated rocks and screes
		2103	Mesophytic mat patches and scarcely vegetated rocks and screes
		2104	Mesophytic and hydrophytic mat patches and scarcely vegetated rocks
		2105	Alpine meadow on the southern side of the Himalaya
		2106	Dry apline vegetation on the northern side of Himalaya
		2107	High altitude discontinuous vegetation cushion plants
		2108	Meadows; mat patches
		2109	Sparsely vegetated rocks and screes of upper alpine level
		2110	Meadows and common land
2.2	Lower alpine	2201	Rhododendron mesohygrophytic scrublands, *Juniperus*… meadows
		2202	Rhododendron mesohygrophytic scrublands (*Rhododendron. anthopogon, R. nivale*)
		2203	Juniper mesohygrophytic scrublands (*Juniperus indica, J. recurva, J. squamata*)
		2204	Xerophytic closed alpine mat and scrub
		2205	Mesophytic closed alpine mat and scrub
		2206	Shrubland with patches of abundant *Rhododendron anthopogon, R. nivale*
3	Sub alpine		
3.1	Upper sub-alpine western	3101	Mesophytic closed alpine mat and scrub (*Rhododendron anthopogon……)*
		3102	Rhododendron - Birch forest (*Betula utilis, Rhododendron. campanulatum*)
		3103	Birch-Blue pine open forest
3.2	Upper sub-alpine Central	3110	North Himalayan alpine vegetation
3.3	Upper sub-alpine Eastern	3120	*Betula utilis* forest Rhododendron…. & *Abies spectablis*
		3121	Rhododendron Shrublands
		3122	Rhododendron -juniper shrublands
3.4	Upper sub-alpine west	3201	Mesophytic Fir forest with oak and Rhododendron
		3202	Hygrophytic Fir-Hemlock-Oak forest
		3203	Fir forest (*Abies spectabilis*)
3.5	Lower sub-alpine	3220	*Abies spectabilis* forest with Rhododendron

	west	3221	*Larix griffithiana* forest
		3222	*Larix griffithiana, L. potanini* forest
		3223	*Larix potanini* forest
3.6	Lower sub-alpine west	8001	High altitude cushion plant formation
		8002	*Caragana versicolor, Lonicera spinosa* steppe
		8003	*Caragana geradiana, Lonicera spinosa* xerophile steppe
		8004	*Caragana brevispina, Artemisia* steppe
		8005	*Caragana pygmaea, Lonicera spinosa* xerophile steppe
		8006	*Myricaria-Hippophae-Salix* reverain thickets
		8007	*Sophora moorcroftiana, Oxytropis mollis* steppe
	Other	9900	Water bodies
4	Montane		
4.1	Montane West	4001	Mesophytic montane Oak-Rhododendron forest
		4002	Mixed Blue Pine-Oak forest
		4003	Mixed hygrophytic Oak-Hemlock -Fir forest
		4004	Open and dry montane Blue Pine forest
		4005	Blue Pine-Spruce forest
		4006	Juniper forest (*Juniperus indica*)
		4007	Rhododendron-Hemlock-Oak forest
		4008	Hemlock forest (*Tsuga dumosa*)
		4009	Mountain Oak forest(*Quercus semecarpifolia*)
		4010	Blue Pine-Spruce -Fir forest
		4011	Spruce mountain forest (*Picea smithiana*)
4.2	Montane Eastern	4020	*Lithocarpus pachyphylla* forest
		4021	*Rhododendron cinnamonmeum* forest
		4022	Deciduous mixed broad-leaved forest
		4023	Mixed broadleaved forest, *Rhododendron-Acer-Symplocos-Lauracea*
		4024	*Daphniphyllum himalayense* forest with a few *Rhododendron grande*
5	Collinean level	5000	Blue Pine-Cypress forest
5.1	Collinean West	5001	Cypress foerst with dwarf barberry
		5002	Collinean Oak forest (*Quercus leucotrichophora, Q.lanata*)
		5003	Mixed Blue Pine-Oak forest
		5004	Mixed Oaks-Laurels forest with shrubs
		5005	Mixed hygrophytic broadleaved forest with oaks
		5006	Cedar forest (*Cedrus deodara*)
		5007	Open Blue Pine forest(*Pinus wallichiana*)
		5008	Collinean Oak-mixed broadleaved forest (*Quercus lanata*)
		5009	*Aesculus, Juglans* riverain forest
		5010	Deciduous broad-leaved forest (*Alnus, Juglans, Acer*)
5.2	Collinean Central	5011	Hygrophytic *Quercus lamellosa* forest

5.3	Collinean Eastern	5012	Hygrophytic forest with *Quercus lamellosa*
		5013	Hygrophytic forest with *Castanopsis tribuloides*
		5014	Mesohygrophytic forest with *Quercus glauca*
		5015	Mesohygrophytic forest with *Quercus lanata, Pinus wallichiqna*
6	Sub Tropical		
6.1	Sub tropical eastern	6001	*Eugenia tetragona, Ostodes paniculata* forest
6.2	Upper Tropical West	6101	Mixed Chir-Pine-Oak forest (*Pinus roxburghii, Quercus. leucotrichophora*)
		6102	*Quercus glauca, Alnus nepalensis, Betula alnoides* riverain forest
		6103	Open *Olea cuspidata* forest
		6105	Sub-tropical mixed broadleaved forest
		6106	*Quercus incana, Schima wallichii* forest
6.3	Upper subtropical Central	6109	Hygrophytic *Schima wallichii, Castanopsis tribuloides* forest
6.4	Upper subtropical Eastern	6110	*Castanopsis tribuloides* forest with *Schima wallichii*…
		6120	*Castanopsis hystrix* forest with *C. tribuloides*….
		6121	*Alnus nepalensis* forest
6.5	Upper and Lower sub tropical west	6201	Chir-Pine forest with grasses and Engrlhardria
		6202	Mixed Chir-Pine Broadleaved forest
		6203	*Alnus nepalensis* riverain forest
		6204	*Euphorbia royleana* steppe in inner valleys
		6207	Grasses-*Artemisia* steppe
6.6	Upper and Lower sub-tropical Central	6210	Hygrophytic S*chima wallichii* forest
6.7	Upper and Lower sub-tropical Eastern	6220	*Schima wallichii, Castanopsis indica* hygrophile forest
		6221	*Schima wallichii, Pinus roxburghii* mesohygrophyle forest
		6222	*Pinus roxburghii* xerophile forest with *Phyllanthus emblica*
		6223	*Schima wallichii, Lagerstoemia parviflora* hygrophile forest
		9003	Pokhara cultivated areas
6.8	Other	9900	Water bodies
		6104	Upper Siwaliks Chir-pine-Oak forest
6.9	Upper sub tropical western	6205	Siwaliks Chir-Pine forest
		6206	Alnus nitida reverain forest
7	Tropical level	7101	Tropical hill Sal forest in large valleys
7.1	Upper tropical west	7102	Tropical riverain forest (*Albizia lebbek, Toona ciliata*…)
		7103	Sal forest in inner valleys (*Shorea robusta, Terminalia tomentosa*)
		7104	Mesophytic tropical forest on southern slopes of the Siwaliks
		7105	Hygrophytic tropical forest on northern slopes of the Siwaliks
		7106	Siwaliks tropical deciduous forest

		7120	Tropical hill Sal forest
7.2	Lower tropical East	7122	Dense forest with *Shorea robusta, Lagerstroemia parviflora* ….
		7123	Dense forest with *Terminalia tomentosa, T.belerica*
		7204	Dun valley Sal forest
7.3	Lower tropical west	9001	Dun cultivated areas
8	Tropical level	7121	Tropical reverain forest
8.1	Upper tropical Eastern	7124	Sal forest (*Shorea robusta*)
		7201	Tarai tropical Sal forest (*Shorea robusta, Terminalia tomentosa*…)
8.2	Lower tropical west	7202	Khair-sissoo riverian forest
		7203	*Bombax ceiba, Trewia nudiflora* riverine forest
		7205	Bhabaar light Sal forest
		7206	Pseudo steppe with Graminae, Tropical elephant grasses
		7220	Tarai tropical Sal forest
8.3	Lower tropical East	7221	Tropical mixed wet forest
		7222	Tropical dense forest with Terminalia
		9000	Cultivated areas…
		9002	Tarai cultivated areas

Appendix C

Forest types identified by TISC

Major Forest Types		Area covered by forest type (in '000 ha)	Main species for each type	
			Trees	**Other species if applicable**
(Stainton, 1972)	**TISC, 2000**			
1. Sal Forest TAwa	Lower Tropical Sal and Mixed Broadleaved Forest	787.20	*Shorea robusta*	*Terminalia* spp.
2. *Dalbergia sissoo-Acacia catechu* Forest TAwa	Lower Tropical Sal and Mixed Broadleaved Forest (Riverine habitat)		*Dalbergia sissoo, Acacia catechu*	*Colebrookea oppositifolia*
3. Tropical Deciduous Riverain Forest TAwa	Hill Sal Forest	1,541.70	*Bombax malabaricam*	*Adina cordifolia, Acacia catechu, Albizia lebbeck*
4. Tropical Evergreen Forest TAwa			*Cedrela toona*	*Garuga pinnata, Albizia* spp.
5. Sub-tropical Deciduous Hill Forest SM			*Anogeissus latifolia*	*Ehretia laevis*
6. Terminalia Forest TAwa			*Termanila* spp.	*Eugenia* spp. *Lagerstroema* spp.
7. Sub-tropical Evergreen Forest SM	*Eugenia-Ostodes* Forest	0.60	*Ostodes paniculata*	*Eugenia tetragona*
8. *Schima - Castanopsis* Forest SM	*Schima-Castanopsis* Forest	460.00	*Schima wallichii*	*Castanopsis indica*
9. Sub-tropical Semi-evergreen Hill Forest SM			*Cedrela toona*	*Albizia chinensis*
10. *Castanopsis tribuloides-C.hystrix* Forest SM			*Castanopsis tribuloides*	*Quercus lamellosa*
11. Alnus Woods SM			*Alnus nepalensis*	*Populus ciliata*
12. *Pinus roxburghii* Forest SM	Chir pine Forest, Chir Pine-Broadleaved Forest	917.20	*Pinus roxburghii*	*Quercus incana*
13. *Quercus incana-Q. lanuginosa* Forest TM	Lower Temperate Oak Forest	408.00	*Quercus incana*	*Pinus roxburghii*
14. *Quercus dilatata* Forest TM			*Quercus dilatata*	*Abies pindrow*
15. *Quercus semecarpifolia* Forest TM	Temperate Mountain Oak Forest,	95.00	*Quercus semecarpifolia*	*Rhododendron arboreum*

	Mountain Oak-Rhododendron Forest, Sub-alpine Mountain Oak Forest			
16. *Quercus lamellosa* Forest TM	East Himalayan Oak-Laurel Forest	154.00	*Quercus lamellosa*	*Castanopsis tribuloides*
17. *Lithocarpus panchyphylla* Forest TM	*Lithocarpus* Forest	5.50	*Lithocarpus panchyphylla*	*Quercus lamellosa*
18. *Aesculus-Juglans-Acer* Forest TM	Deciduous Walnut-Maple-Alder Forest	Insignificant	*Aesculus indica*	*Juglans regia, Acer caesium*
19. Lower Temperate Mixed Broadleaved Forest TM	Mixed Rhododendron-Maple Forest	37.80	*Machilus duthiei*	*Cinnamommum tamala*
20. Upper Temperate Mixed Broadleaved Forest TM	Deciduous Maple-*Magnolia-Sorbus* Forest	11.40	*Acer campbellii*	*Magnolia campbellii*
21. *Rhododendron* Forest TM	Rhododendron Forest	7.70	*Rhododendron arboreum*	*Gaultheria hookeri*
22. *Betula utilis* Forest TM	Birch-Rhododendron Forest	158.10	*Betula utilis*	*Prunus cornuta*
23. *Abies spectabilis* Forest TM	Fir-Blue Pine Forest, Fir Forest, Fir-Oak-Rhododendron Forest,	367.40	*Abies spectabilis*	*Betula utilis, Tsuga dumosa*
24. *Tsuga dumosa* Forest TM	Fir-Hemlock-Oak Forest	36.90	*Tsuga dumosa*	*Lithocarpus panchyphylla*
25. *Pinus wallichiana* Forest TM	Upper Temperate Blue Pine Forest, Mixed Blue Pine-Oak Forest	28.10	*Pinus wallichiana*	*Picea smithiana*
26. *Picea smithiana* Forest TM	Spruce Forest	65.90	*Picea smithiana*	*Pinus wallichiana*
27. *Abies pindrow* Forest TM	West Himalayan Fir-Hemlock-Oak Forest	29.70	*Abies pindrow*	*Picea smithiana*
28. *Cedrus deodara* Forest Ba	Cedar Forest	4.55	*Cedrus deodara*	*Pinus wallichiana*
29. *Cupressus torulosa* Forest Ba	Cypress Forest	4.50	*Cupressus torulosa*	*Wikstroemia canescens*
30. Larix Forest BM	Larch Forest	6.20	*Larix grifithiana*	*Abies spectabilis*
31. *Populus ciliata* Woods BM	Trans-Himalayan Lower *Caragana* Steppe	412.10	*Populus ciliata*	*Picea smithiana*
32. Hippophae Scrub			*Hippophae*	*Populus ciliate*

BM	(Riverine habitat)		*salisifolia*	
33. Moist Alpine Scrub BM	Moist Alpine Scrubs	3.40	*Rhododendron campanulatum*	*Juniperus recurva*
34. Dry Alpine Scrub BM	Dry Alpine Scrubs	0.25	*Juniperus recurva*	*Juniperus wallichiana*
35. Juniper wallichiana Forest TM	Temperate Juniper Forest	Insignificant	*Juniperus wallichiana*	*Betula utilis*

Source: TISC (2011)

Appendix D

List of tree species

SN	**Species (Scientific name)**	**N or E**	**Family**	**Type of management system**	**Physiographic zones**	**Distribution**
1	*Abies pindrow*	N	Pinaceae	Natural	MM, HM	C/W
2	*Abies spectabillis*	N	Pinaceae	Natural	MM, HM	C/W
3	*Acacia catechu*	N	Leguminosae	Natural and farm	T, S	E/C/W
4	*Acacia nilotica*	E	Leguminosae	Plantation	T,S	E/C/W
5	*Acer acuminatum*	N	Aceraceae	Natural	MM, HM	E/C/W
6	*Acer caesium*	N	Aceraceae	Natural	MM, HM	E/C/W
7	*Acer campbellii*	N	Aceraceae	Natural	MM, HM	E/C/W
8	*Acer cappadocicum*	N	Aceraceae	Natural	MM, HM	W
9	*Acer caudatum*	N	Aceraceae	Natural	MM, HM	E/C
10	*Acer hookeri*	N	Aceraceae	Natural	MM, HM	E
11	*Acer oblongum*	N	Aceraceae	Natural	HM	E/C/W
12	*Acer pectinatum*	N	Aceraceae	Natural	MM, HM	E/C/W
13	*Acer sikkimense*	N	Aceraceae	Natural	S,MM	E/W
14	*Acer sterculiaceum*	N	Aceraceae	Natural	MM, HM	E/C/W
15	*Acer thomsonii*	N	Aceraceae	Natural	MM, HM	E
16	*Acrocarpus fraxinifolius*	N	Leguminosae	Natural	T, S	E
17	*Actinodaphne angusifolia*	N	Lauraceae	Natural	S, MM	C
18	*Actinodaphne obovata*	N	Lauraceae	Natural	S, MM	E
19	*Actinodaphne reticulata*	N	Lauraceae	Natural	S, MM	E
20	*Actinodaphne sikkimensis*	N	Lauraceae	Natural	S, MM	E
21	*Adina cordifolia*	N	Rubiaceae	Natural	T,S	E/C/W
22	*Aegle marmelos*	N	Rutaceae	Natural, Farm	T, S	E/C/W
23	*Aesandra butyracea*	N	Sapotaceae	Natural	MM	E/C/
24	*Aesculus indica*	N	Hippocastanaceae	Natural	S, MM, HM	C/W
25	*Ailanthus excelsa*	E	Simaroubaceae	Plantation	T	E/C/W
26	*Albizia chinensis*	N	Leguminosae	Natural, Farm	T,S	E/C
27	*Albizia gamblei*	N	Leguminosae	Natural	S, MM	E
28	*Albizia julibrissin*	N	Leguminosae	Natural	S, MM, HM	E/C/W
29	*Albizia lebbek*	N	Leguminosae	Natural, Farm	T,S	E/C/W
30	*Albizia procera*	N	Leguminosae	Natural, Farm	T,S	E/C
31	*Alibizia lucidior*	N	Leguminosae	Natural	T, S, MM	E/C
32	*Alnus nepalensis*	N	Betulaceae	Natural and plantation	MM,HM	E/C
33	*Alstonia scholaris*	N	Apocynaceae	Natural	T, S, MM	E/C

34	*Anogeissus latifolius*	N	Combretaceae	Natural	T,S	E/C/W
35	*Anthocephalus chinensis*	N	Rubiaceae	Farm	T,S	E/C
36	*Antidesma acidum*	N	Euphorbiaceae	Natural, Farm	T, S, MM	E/C
37	*Antidesma acuminatum*	N	Euphorbiaceae	Natural, Farm	T, S, MM	E
38	*Aporusa octandra*	N	Euphorbiaceae	Natural	T, SS, MM	E/C
39	*Artocarpus lakoocha*	N	Moraceae	Farm	MM	E/C/W
40	*Astragalus polyacanthus*	N	Leguminosae	Natural	S, MM, HM	C
41	*Azadirachta indica*	N	Meliaceae	Farm	T,S	E/C/W
42	*Baccaurea ramiflora*	N	Euphorbiaceae	Natural	T, S, MM	E/C
43	*Bassia butyracea*	N	Sapotaceae	Natural, Farm	MM,S	C/W
44	*Bassia latifolia*	N	Sapotaceae	Natural, Farm	T,S	E/C/W
45	*Bauchanania latifolia*	N	Anacardiaceae	Natural	S, MM	C/W
46	*Bauhinia semal*	N	Leguminosae	Natural	S, MM	C/W
47	*Bauhinia purpurea*	N	Leguminosae	Natural	MM,S,T	E/C/W
48	*Bauhinia variegata*	N	Leguminosae	Farm	MM,S,T	E/C/W
49	*Bauinia malabarica*	N	Leguminosae	Natural	T, S, MM	E//C
50	*Benthamidia capitata*	N	Cornaceae	Natural	HM,MM	C/W
51	*Betula utilis*	N	Betulaceae	Natural	MM, HM, HH	E/C/W
53	*Betula alnoides*	N	Betulaceae	Natural	HM,MM	E/C/W
54	*Bischofia javanica*	N	Staphyleaceae	Natural	T, SS, MM	E/C/W
55	*Boehmeria rugulosa*	N	Urticaceae	Natural	MM	E/C/W
56	*Bombax ceiba*	N	Bombacaceae	Natural, Farm	T,S	E/C/
57	*Brassaiopsis aculeata*	N	Araliaceae	Natural	S, MM	E/C/
58	*Brassaiopsis alpina*	N	Araliaceae	Natural	MM, HM	E
59	*Brassaiopsis capitata*	N	Araliaceae	Natural		E
60	*Brassaiopsis glomerulata*	N	Araliaceae	Natural, Farm	MM	E/E
61	*Brassaiopsis mitis*	N	Araliaceae	Natural	S, MM	E/E
62	*Brassiopsis hainla*	N	Araliaceae	Natural, Farm	MM	E/C/W
63	*Bridelia retusa*	N	Euphorbiaceae	Farm	MM	E/C/W
64	*Butea monosperma*	N	Leguminosae	Farm	T,S	E/C/W
65	*Callicarpa arborea*	N	Verbenaceae	Natural	T,S	E/C/W
66	*Careya arborea*	N	Lecythidaceae	Natural	T, S, MM	E/C/
67	*Carpinus viminea*	N	Corylaceae	Natural	S, MM, HM	E/C/W
68	*Cassia fistula*	N	Leguminosae	Natural	T,S	E/C/W
69	*Cassia siamea*	N	Leguminosae	Natural	T,S	E/C/W
70	*Cassine glauca*	N	Celastraceae	Natural	T, S, MM	E/C/
71	*Castanopsis hystirx*	N	Fagaceae	Natural	S, MM , HM	E/C
72	*Castanopsis indica*	N	Fagaceae	Natural	MM	E/C/
73	*Castanopsis tribuloides*	N	Fagaceae	Natural, Farm	MM	E/C/W
74	*Cedrus deodara*	N	Pinaceae	Natural	S, MM, HM	C/W
75	*Cedrela toona*	N	Meliaceae	Natural, Farm	T,S	C/W/E

76	*Celtis australis*	N	Ulmaceae	Natural	MM,HM	C
77	*Celtis terandra*	N	Ulmaceae	Natural	S, MM, HM	E/C/W
78	*Choerospondias axillaris*	N	Anacardiaceae	Farm	MM	E/C
79	*Cinnamomum bejolghota*	N	Lauraceae	Natural	S, MM	E/
80	*Cinnamomum camphora*	E	Lauraceae	Farm	S,MM	E/C/W
81	*Cinnamomum glanduliferum*	N	Lauraceae	Natural	S, MM, HM	/C/W
82	*Cinnamomum glaucescens*	N	Lauraceae	Natural	S,MM	E/W
83	*Cinnamomum tamala*	N	Lauraceae	Natural	S,MM	E/C/W
83	*Clausena excavata*	N	Rutaceae	Natural	T, S, MM	E/C/
84	*Cleidion spiciflorum*	N	Euphorbiaceae	Natural	S, MM	E
85	*Cordia dichotoma*	N	Cordiaceae	Natural	T,S,MM	E/C
86	*Corylus ferox*	N	Corylaceae	Natural	MM, HM	E/C/W
87	*Corylus jacquemontii*	N	Corylaceae	Natural	S, MM, HM	W
88	*Cotoneaster frigidus*	N	Rosaceae	Natural	T,S	C/W
89	*Crataeva religiosa*	N	Capparaceae	Natural	T,S	C/W
90	*Croton roxburghii*	N	Euphorbiaceae	Natural	T, S, MM	E/C
91	*Cryptomeria japonica*	E	Taxodiaceae	Plantation	MM	E/C
92	*Crytocarya amygdalina*	N	Lauraceae	Natural	T, S, MM	E/C
93	*Cupressus torulosa*	N	Cupressaceae	Natural	S, MM, HM	C/W
94	*Dalbergia latifolia*	N	Leguminosae	Natural	T,S	E/C/W
95	*Dalbergia serica*	N	Leguminosae	Natural	S, MM	E/C/W
96	*Dalbergia sissoo*	N	Leguminosae	Natural and plantation	T,S	E/C/W
97	*Daphne bholua*	N	Thymelaeaceae	Natural	MM	E/C/W
98	*Daphniphyllum himalense*	N	Daphniphyllaceae	Natural	S, MM, HM	E/C/W
99	*Dendrocalamus hamiltonii*	N	Graminae	Natural	T,S	E/C/W
100	*Dendrocalamus strictus*	N	Graminae	Natural	T,S	E/C/W
101	*Desmodium oojeinense*	N	Leguminosae	Natural	S, MM	/C
102	*Dillenia indica*	N	Dilleniaceae	Natural	T, S	E
103	*Dillenia pentagyna*	N	Dilleniaceae	Natural	T, S, MM	E/C/
104	*Diospyrous montana*	N	Ebenaceae	Natural	S, MM	E/W
105	*Diospyrus malabarich*	N	Ebenaceae	Natural	S, MM	W
106	*Diospyrus melanoxylon*	N	Ebenaceae	Natural, Farm	T, S	
107	*Dodecadenia grandiflora*	N	Lauraceae	Natural	MM, HM	E/C/W
108	*Drimycarpus racemosus*	N	Anacardiaceae	Natural	S, MM	E
109	*Duabanga grandiflora*	N	Sonneratiaceae	Natural	T, SS, MM	E/C
110	*Dysoxylum binectariferum*	N	Meliaceae	Natural	T, S	E/C
111	*Dysoxylum gobara*	N	Meliaceae	Natural	T, S, MM	E/C
112	*Ehretia acuminata*	N	Cordiaceae	Natural	T, S, MM	E/C/W

113	*Ehretia laevis*	N	Cordiaceae	Natural	T, S, MM	E/C
114	*Ehretia macrophylla*	N	Cordiaceae	Natural	S, MM, HM	E/C
115	*Ehretia wallichiana*	N	Cordiaceae	Natural	T, S, MM	E
116	*Elaeocarpus sphaericus*	N	Elaeocarpaceae	Farm	S, MM	E/C
117	*Phyllanthus emblica*	N	Euphorbiaceae	Natural, Farm	T,S	E/C/W
118	*Engelhardtia spicata*	N	Sapotaceae	Natural, Farm	MM	
119	*Enkianthus deflexus*	N	Ericaceae	Natural	MM, HM	E
120	*Ephedra gerardiana*	N	Ephedraceae	Natural	HM, HH	C/W
121	*Eriobotrya elliptica*	N	Rosaceae	Natural	T, S, MM	E/C/W
122	*Erythrina arborescens*	N	Leguminosae	Farm	S, MM	E/C/W
123	*Erythrina stricta*	N	Leguminosae	Natural	T,S	E/C/W
124	*Erythrina suberosa*	N	Leguminosae	Natural	S, MM	E/C/W
125	*Eucalyptus camaldulensis*	E	Myrtaceae	Plantation, Farm	T	E/C/W
126	*Eugenia ramosissima*	N	Myrtaceae	Natural	S, MM	E
127	*Euonymus* spp.	N	Celastraceae	Natural	MM, HM	E/C/W
128	*Exbucklandia populnea*	N	Hamamelidaceae	Natural	S, MM, HM	E
129	*Excoecaria acerifolia*	N	Euphorbiaceae	Natural	MM, HM	C/W
130	*Ficus arnottiana*	N	Moraceae	Natural	S, MM, HM	E/W
131	*Ficus auriculata*	N	Moraceae	Farm	T, S,MM	E/C
132	*Ficus bengalensis*	N	Moraceae	Natural, Farm	T	E/C/W
133	*Ficus benjamina*	N	Moraceae	Natural	S, MM	C/W
134	*Ficus glaberrima*	N	Moraceae	Natural	MM	C
135	*Ficus glomerata*	N	Moraceae	Natural, Farm	T, S,MM	E/C
136	*Ficus hispida*	N	Moraceae	Farm	MM	E/C/W
137	*Ficus lacor*	N	Moraceae	Farm	S,MM	E/C/
138	*Ficus neriifolia*	N	Moraceae	Farm	MM,HM	E/C/
139	*Ficus nemoralis*	N	Moraceae	Natural	MM	E/C/
140	*Ficus semicordata*	N	Moraceae	Farm	T,S,MM	E/C/W
141	*Flacourtia indica*	N	flacouticeae	Natural	T, S, MM	E/C/W
142	*Fraxinus floribunda*	N	Oleaceae	Farm	MM,HM	E/C
143	*Gamblea ciliata*	N	Araliaceae	Natural	MM, HM	E/C
144	*Garcinia xanthochymus*	N	Guttiferae	Natural	T, S	E
145	*Garuga pinnata*	N	Burserceae	Natural, Farm	T,S	E/C/W
146	*Glochidion lanceolarium*	N	Euphorbiaceae	Natural	T, S, MM	E/C
147	*Glochidion metanbigenum*	N	Euphorbiaceae	Natural	S, MM	E
148	*Glochidion velutinum*	N	Euphorbiaceae	Natural	T, S, MM	E/C/W
149	*Gmelina arborea*	N	Verbenaceae	Natural	T,S	E/W
150	*Grewia optiva*	N	Tiliaceae	Natural, Farm	T,S	E/C/W
151	*Guazuma ulmifolia*	E	Sterculiaceae	Plantation, Farm	T	E/C/W
152	*Gynocardia odorata*	N	Flacourtiaceae	Natural	S, MM	E

153	*Heteropanax fragrans*	N	Araliaceae	Natural	S, MM	E/C
154	*Holarrhena pubescens*	N	Apocynaceae	Natural	T,S	E/C/W
155	*Holoptelea integrifolia*	N	Ulmaceae	Natural	T, S, MM	E
156	*Horsfieldia kingii*	N	myristicaceae	Natural	T, S	E
157	*Hymenodictyon excelsum*	N	Rubiaceae	Natural	T, S	E/C
158	*Hymenodictyon flaccidum*	N	Rubiaceae	Natural	S, MM	E/C/W
159	*Ilex dipyrena*	N	Aquifoliaceae	Natural	MM, HM	E/C/W
160	*Ilex fragilis*	N	Aquifoliaceae	Natural	MM, HM	E/C
161	*Ilex insignis*	N	Aquifoliaceae	Natural	S, MM, HM	E
162	*Ilex sikkimensis*	N	Aquifoliaceae	Natural	MM, HM	E
163	*Indopiptadenia oudhensis*	N	Leguminosae	Natural	S	W
164	*Juglans regia*	N	Juglandaceae	Natural	S, MM	E/C/W
165	*Juniperus* spp.	N	Cupressaceae	Natural, Farm	MM, HM	E/C/W
166	*Kydia calycina*	N	Malvaceae		T, S, MM	E/C/W
167	*Lagerstroemia parviflora*	N	Lythraceae	Natural	T,S	E/C/W
168	*Lannea coromandelica*	N	Anacardiaceae	Natural	T, S, MM	E/C/W
169	*Larix griffithiana*	N	Pinaceae	Natural	S,MM,HM	E/C
170	*Larix himalaica*	N	Pinaceae	Natural	MM, HM	C
171	*Leucaena diversifolia*	E	Leguminosae	Natural	T,S	E/C/W
172	*Leuceana leucocephala*	E	Leguminosae	Natural	T,S	E/C/W
173	*Leucosceptrum canum*	N	Labiatae	Natural	S, MM, HM	E/C/W
174	*Ligustrum confusum*	N	Oleaceae	Natural	S, MM, HM	E/C/M
175	*Ligustrum indicum*	N	Oleaceae	Natural	S, MM, HM	E/C/M
176	*Lindera assamica*	N	Lauraceae	Natural	T, S, MM, HM	E
177	*Lindera heterophylla*	N	Lauraceae	Natural	MM, HM	E
178	*Lindera neesiana*	N	Lauraceae	Natural	S, MM, HM	E/C
179	*Lindera pulcherrima*	N	Lauraceae	Natural	S,MM,HM	E/C/W
180	*Lisea doshia*	N	Fagaceae	Natural	S, MM, HM	E/C/
181	*Lithocarpus elegans*	N	Fagaceae	Natural	S, MM, HM	E/C/W
182	*Lithocarpus fenestrata*	N	Fagaceae	Natural	S, MM	E
183	*Lithocarpus pachyphylla*	N	Fagaceae	Natural	MM, HM	E
184	*Litsea cubeba*	N	Lauraceae	Natural	S, MM, HM	E/C
185	*Litsea doshia*	N	Lauraceae	Natural	S, MM	E/C/
186	*Litsea elongata*	N	Lauraceae	Natural	S, MM, HM	E/C
187	*Litsea glutinosa*	N	Lauraceae	Natural	T, S, MM	E/C
188	*Litsea lancifolia*	N	Lauraceae	Natural	S, MM	E/C/W
189	*Litsea monopetala*	N	Lauraceae	Natural	T,S,MM	E/C
190	*Litsea salicifolia*	N	Lauraceae	Natural	T, S, MM	E/C
191	*Litsea sericea*	N	Lauraceae	Natural	MM, HM	E/C

192	*Lonicera minutifolia*	N	Caprifoliaceae	Natural	MM, HM, HH	C
193	*Lonicera myrtilloides*	N	Caprifoliaceae	Natural	HM, HH	C/W
194	*Lonicera quinquelocularis*	N	Caprifoliaceae	Natural	S, MM, HM	C/W
195	*Lyonia ovalifolia*	N	Ericaceae	Natural, Farm	MM	E/C/W
196	*Lyonia villosa*	N	Ericaceae	Natural	MM, HM	E/C/W
197	*Macaranga denticuata*	N	Euphorbiaceae	Natural	T, S, MM	E/C/
198	*Macaranga pustulata*	N	Euphorbiaceae	Natural	S, MM	E/C/W
199	*Macaranga undulatus*	N	Euphorbiaceae	Natural	T, S, MM	E/C
200	*Machilus* spp.	N	Lauraceae	Natural, Farm	MM	
201	*Macropanax dispermus*	N	Araliaceae	Farm	S, MM, HM	E/C
202	*Maddenia himalaica*	N	Rosaceae	Natural	MM, HM	E
203	*Maesa chisia*	N	Myrsinaceae	Natural	S, MM, HM	E/C/W
204	*Maesa macrophylla*	N	Myrsinaceae	Natural	T, S, MM	E/C/
205	*Maesa montana*	N	Myrsinaceae	Natural	T, S, MM	E/C/W
206	*Magnolia campbellii*	N	Magnoliaceae	Natural	MM, HM	E/C
207	*Magnolia globosa*	N	Magnoliaceae	Natural	HM	E//E
208	*Mallotus nepalensis*	N	Euphorbiaceae	Natural	S, MM	E/C
209	*Mallotus philippensis*	N	Euphorbiaceae	Natural, Farm	T,S	E/C/W
210	*Mallotus sylvatica*	N	Euphorbiaceae	Natural	S, MM	E
211	*Mallotus tetracoccus*	N	Euphorbiaceae	Natural	T,S, MM	E/C
212	*Mallus sikkimensis*	N	Rosaceae	Natural	MM, HM	C/W
213	*Malus baccata*	N	Rosaceae	Natural	S,MM,HM	C/W
214	*Mangifera indica*	N	Anacardiaceae	Farm	T,S	E/C/W
215	*Mangifera sylvatica*	N	Anacardiaceae	Natural	S, MM	E
216	*Maytenus rufa*	N	Celastraceae	Natural	S, MM, HM	E/C/W
217	*Melia azedarach*	N	Meliaceae	Natural, Farm	T,S	E/C/W
218	*Melia dubia*	N	Meliaceae	Natural	S, MM	E
219	*Meliosma dilleniifolia*	N	Sabiaceae	Natural	S, MM, HM	E/C/W
220	*Meliosma pinnata*	N	Sabiaceae	Natural	T, S	E/C/
221	*Meliosma simplicifolia*	N	Sabiaceae	Natural	T, S, MM, HM	E/C/W
222	*Michelia champaca*	N	Magnoliaceae	Natural, Farm	MM,HM	E/C/
223	*Michelia doltsopa*	N	Magnoliaceae	Natural	MM, HM	E/C
224	*Michelia kisopa*	N	Magnoliaceae	Natural	MM	E/C/W
225	*Michelia velutina*	N	Magnoliaceae	Natural	T, S, MM	E/C/
226	*Micromelum integerrimum*	N	Rutaceae	Natural	T, S, MM	E/C/
227	*Mitragyna parviflora*	N	Rubiaceae	Natural	T, S	E/C/W
228	*Morinda angustifolia*	N	Rubiaceae	Natural	T, S	E/C/
229	*Morus alba*	E	Sabiaceae	Farm, Plantation	T,S	E/C/W
230	*Morus serrata*	N	Sabiaceae	Farm	S, MM, HM	C/W
231	*Myrica esculenta*	N	Myricaceae	Natural, Farm	MM,S	C/W

232	*Myrsine semiserrata*	N	Myrsinaceae	Natural	S, MM, HM	E/C/W
233	*Neocinnamomum caudatum*	N	Lauraceae	Natural	S, MM	C
234	*Neolitsea cuipala*	N	Lauraceae	Natural	S, MM	E/C
235	*Neolitsea pallens*	N	Lauraceae	Natural	S, MM, HM	E/C/W
236	*Neolitsea umbrosa*	N	Lauraceae	Natural	MM	C
237	*Olea ferruginea*	N	Oleaceae	Natural	S, MM, HM	W
238	*Olea glandulifera*	N	Oleaceae	Natural	S, MM	C/W
239	*Ormosia glauca*	N	Leguminosae	Natural	S, MM	C/W
240	*Oroxylum indicum*	N	Bignoniaceae	Natural	S, MM	E/C/W
241	*Osmanthus fragrans*	N	Oleaceae	Natural	MM, HM	C/W
242	*Osmanthus suavis*	N	Oleaceae	Natural	MM, HM	E/C
243	*Ostodes paniculata*	N	Euphorbiaceae	Natural	S, MM	C/W
244	*Osyris wightiana*	N	Santalaceae	Natural	S, MM, HM	E/C
245	*Pandanus nepalensis*	N	Pandanaceae	Natural	S, MM	C/
246	*Pavetta indica*	N	Rubiaceae	Natural	T, S, MM	E/C/
247	*Pavetta tomentosa*	N	Rubiaceae	Natural	T, S, MM	E/C/
248	*Pentapanax leschenaultii*	N	Araliaceae	Natural	S,MM,HM	E/C/W
249	*Persea clarkeana*	N	Lauraceae	Natural	MM, HM	E/C/W
250	*Persea duthiei*	N	Lauraceae	Natural	S, MM, HM	E/C/W
251	*Persea odoratissima*	N	Lauraceae	Natural	S, MM, HM	E/C/W
252	*Persea villosa*	N	Lauraceae	Natural	S, MM	E
253	*Phoebe attenuata*	N	Lauraceae	Natural	S, MM	E/C
254	*Phoebe cathia*	N	Lauraceae	Natural	S, MM	E/C
255	*Phoebe lanceolata*	N	Lauraceae	Natural	T, S, MM	E/C/W
256	*Photinia integirfolia*	N	Rosaceae	Natural	S, MM, HM	E/C/
257	*Phyllanthus emblica*	N	Euphorbiaceae	Natural	T,S	E/C/W
258	*Picea smithiana*	N	Pinaceae	Natural	MM,HM	C/W
259	*Picrasma javanica*	N	Simaroubiaceae	Natural	S, MM	E
260	*Pieris formosa*	N	Ericaceae	Natural	MM, HM	E/C
261	*Pinus patula*	N	Pinaceae	Natural	MM,HM	E/C
262	*Pinus roxburghii*	N	Pinaceae	Natural and plantation	S,MM	E/C/W
263	*Pinus wallichiana*	N	Pinaceae	Natural	MM,HM	E/C/W
264	*Pistacia chinensis* subspp.*integerrim*	N	Anacardiaceae	Natural	S, MM, HM	W
265	*Pistacia khinjuk*	N	Anacardiaceae	Natural	S, MM	W
266	*Podocarpus neriifolius*	N	Podocarpaceae	Natural	S, MM	E
267	*Populus ciliata*	N	Salicaceae	Natural and plantation	HM	E
268	*Populus jacquemontiana*	N	Salicaceae	Plantation	MM, HM	E
269	*Premna barbata*	N	Verbenaceae	Natural	S, MM	E/C/W
270	*Premna integrifolia*	N	Verbenaceae	Natural, Farm	T,S	E/C

271	*Premna latifolia*	N	Verbenaceae	Natural, Farm	MM, S	E/C
272	*Prunus cerasoides*	N	Rosaceae	Natural, Farm	MM,HM	E/C/W
273	*Prunus cornuta*	N	Rosaceae	Natural	MM, HM	E/C/W
274	*Prunus himalaica*	N	Rosaceae	Natural	HM	C
275	*Prunus napaulensis*	N	Rosaceae	Natural	S, MM, HM	E/C/W
276	*Prunus rufa*	N	Rosaceae	Natural	HM	E/C/W
277	*Prunus undulata*	N	Rosaceae	Natural	MM, HM	E/C
278	*Prunus venosa*	N	Rosaceae	Natural	S, MM, HM	E/C/W
279	*Pterocarpus marsupium*	N	Leguminosae	Natural	T	W
280	*Pterosperum acerifolium*	N	Sterculiaceae	Natural	S, MM	E
281	*Punica granatum*	N	Puniceae	Natural	S, MM , HM	E/C/W
282	*Pyrularia edulis*	N	Santalaceae	Natural	S, MM	E/C/W
283	*Pyrus pashia*	N	Rosaceae	Farm	MM,HM	
284	*Quercus sp.*	N	Fagaceae	Natural	MM,HM	E/C/W
285	*Randia dumetorum*	N	Rubiaceae	Natural	T,S	
286	*Rhamnus purpureus*	N	Rhamnaceae	Natural	MM	C/W
287	*Rhamnus virgatus*	N	Rhamnaceae	khasru	S, MM, HM	E/C/W
288	*Rhododendron arboreum*	N	Ericaceae	Natural	s, MM, HM	E/c/w
289	*Rhododendron barbatum*	N	Ericaceae	Natural	MM, HM	E/C/W
290	*Rhododendron cinnabarinum*	N	Ericaceae	Natural	HM	E
291	*Rhododendron falconeri*	N	Ericaceae	Natural	MM,HM	E
292	*Rhododendron fulgens*	N	Ericaceae	Natural	HM	E
293	*Rhododendron grande*	N	Ericaceae	Natural	S,MM	E
294	*Rhododendron griffithianum*	N	Ericaceae	Natural	MM, HM	E
295	*Rhododendron hodgsonii*	N	Ericaceae	Natural	MM, HM	E
296	*Rhododendron lindleyi*	N	Ericaceae	Natural	MM, HM	E
297	*Rhododendron wightii*	N	Ericaceae	Natural	HM, HH	E
298	*Rhus javanica*	N	Anacardiaceae	Natural	MM	E/C/W
299	*Rhus punjabensis*	N	Anacardiaceae	Natural	MM, HM	/C/W
300	*Rhus succedanea*	N	Anacardiaceae	Natural	S, MM, HM	E/C/W
301	*Rhus wallichii*	N	Anacardiaceae	Natural	T, S, MM, HM	E/C/W
302	*Salix daltoniana*	N	Salicaceae	Natural	HM, NN	E/C/
303	*Salix dendiculata*	N	Salicaceae	Farm	MM	E/C/W
304	*Salix longiflora*	N	Salicaceae	Natural	MM, HM	C
305	*Sapindus mukorossi*	N	Sapindaceae	Natural, Farm	MM,S	E//W
306	*Sapium baccata*	N	Euphorbiaceae	natural	T, S, MM	E/C
307	*Sapium insigne*	N	Euphorbiaceae	Natural	S, MM	E/C/W
308	*Saurauia napaulensis*	N	Saurauiaceae	Farm	MM,HM	E/C/W
309	*Saurauia roxburghii*	N	Saurauiaceae	Natural	T, S, MM	E
310	*Schefflera impressa*	N	Araliaceae	Natural	MM,HM	E/C
311	*Schefflera venulosa*	N	Araliaceae	Natural	T, S, MM	C/W

312	*Schima wallichii*	N	Theaceae	Natural, Farm	MM,S	C/W
313	*Schleichera oleosa*	N	Sapindaceae	Natural	T, S	E/C/W
314	*Semecarpus anacardium*	N	Anacardiaceae	Natural	T, S, MM	E/C/W
315	*Sesbania grandiflora*	N	Leguminosae	Natural	T,S	E/C/W
316	*Shorea robusta*	N	Dipterocarpaceae	Natural	T,S	E/C/W
317	*Skimmia arborescens*	N	Rutaceae	Natural	S, MM, HM	E/C
318	*Sloanea sterculiaceus*	N	Elaeocarpaceae	Natural	T, S	E
319	*Sorbus controversa*	N	Rosaceae	Natural	S	C
320	*Sorbus cuspidata*	N	Rosaceae	Natural	MM,HM	E/C/W
321	*Sorbus floiolosa*	N	Rosaceae	Natural	MM,NM	E/C/W
322	*Sorbus lanata*	N	Rosaceae	Natural	MM,HM	C/W
323	*Sorbus microphylla*	N	Rosaceae	Natural	MM, HM, HH	E/C/W
324	*Sorbus rhamnoides*	N	Rosaceae	Natural	MM, HM	E//
325	*Sorbus ursina*	N	Rosaceae	Natural	MM,HM,HH	E/C/W
326	*sorbus hedlundii*	N	Rosaceae	Natural	MM,HM	E
327	*Sphaerosacme decandra*	N	Meliaceae	Natural	T, S, MM	E/C
328	*Spondias pinnata*	N	Anacardiaceae	Natural	T, S, MM	E/C/W
329	*Stachyrucus himalaicus*	N	Stachyuraceae	Natural	S, MM	E/C
330	*Staphylea emodi*	N	Staphyleaceae	Natural	MM, HM	W
331	*Sterculia hamiltonii*	N	Sterculiaceae	Natural	T, S, MM	E/C
332	*Sterculia villosca*	N	Sterculiaceae	Natural	MM	E/C/W
333	*Stereospermum chelonoides*	N	Bignoniaceae	Natural	T, S	E/C/W
334	*Stranvaesia nussia*	N	Rosaceae	Natural	S, MM, HM	E/C/W
335	*Streblus asper*	N	Moraceae	Natural	T, S, MM	E/C/
336	*Styrax hookeri*	N	Styracaceae	Natural	S, MM, HM	E
337	*Swida controversa*	N	Cornaceae	Natural	S, MM	C
338	*Swida oblonga*	N	Cornaceae	Natural	S, MM, HM	E/C/W
339	*Symplocos dryophila*	N	Symplocaceae	Natural	S, MM, HM	E//E
340	*Symplocos paniculata*	N	Symplocaceae	Natural	S, MM	E/C/W
341	*Symplocos pyrifolia*	N	Symplocaceae	Natural	S, MM	E
342	*Symplocos racemosa*	N	Symplocaceae	Natural	T, S, MM	E/C
343	*Symplocos ramosissima*	N	Symplocaceae	Natural	S, MM, HM	E/C/W
344	*Symplocos sumuntia*	N	Symplocaceae	Natural	S, MM , HM	E/C
345	*Symplocos theifolia*	N	Symplocaceae	Natural	S,MM	E/C/W
346	*Syringa emodi*	N	Oleaceae	Natural	MM,HM	C/W
347	*Syzygium cumini*	N	Myrtaceae	Natural	T,S	E/C/W
348	*Syzygium tetragonum*	N	Myrtaceae	Natural	T, S, MM	E
349	*Syzygium venosum*	N	Myrtaceae	natural	T, S	E/C/W
350	*Syzygium wallichii*	N	Myrtaceae	Natural, Farm	T, S	E
351	*Talauma hodgsonii*	N	Magnoliaceae	natural	S, MM	E/C
352	*Taxus wallichiana*	N	Taxaceae	Natural	MM,HM	E/C/W
353	*Tectona grandis*	E	Verbenaceae	Plantation	T,S	E/C/W

354	*Terminalia alata*	N	Combretaceae	Natural	T,S	E/C/W
355	*Terminalia belerica*	N	Combretaceae	Natural, Farm	T,S	E/C
356	*Terminalia chebula*	N	Combretaceae	Natural, Farm	T,S, MM	E/C
357	*Terminalia myriocarpa*	N	Combretaceae	Natural	S, MM	E/C/
358	*Tetracentron sinense*	N	Tetracentraceae	Natural	MM,HM	E
359	*Toona ciliata*	N	Meliaceae	Natural	MM	C/W
360	*Toona serrata*	N	Meliaceae	Natural	MM, HM	C/W
361	*Trema orientalis*	N	Ulmaceae	Natural	T, S, MM	E
362	*Trema politoria*	N	Ulmaceae	Natural	S, MM	E
363	*Trevesia palmata*	N	Araliaceae	Natural	T, S, MM, HM	E/C/
364	*Trewia nudiflora*	N	Euphorbiaceae	Natural	T, S, MM	E/C/W
365	*Trichilia connaroides*	N	Meliaceae	Natural	S, MM, HM	E/C/W
366	*Tsuga dumosa*	N	Pinaceae	Natural	MM, HM	E/C/W
367	*Turpinia pamifera*	N	staphyleaceae	Natural	T, S, MM	E
368	*Turpinia nepalensis*	N	staphyleaceae	Natural	S, MM	E/C/
369	*Ulmus lanceifolia*	N	Ulmaceae	Natural	T, S, MM, HM	E
370	*Ulmus wallichiana*	N	Ulmaceae	Natural	S,MM	W
371	*Vernonia talaumifolia*	N	compositae	Natural	T, S, MM	E
372	*Vitex peduncularis*	N	Verbenaceae	Natural	T, S, MM	E
373	*Wendlandia appendiculata*	N	Rubiaceae	Natural	S, MM	C
374	*Wendlandia coriacea*	N	Rubiaceae	Natural	T, S, MM	E/C/W
375	*Wendlandia puberula*	N	Rubiaceae	Natural	S, MM	E/C/W
376	*Wendlandia exserta*	N	Rubiaceae	Natural	S, MM	E/C/W
377	*Wightia specisissima*	N	Scrophulariaceae	Natural	S, MM, HM	E/C/
378	*Xylosma controversum*	N	Flacourtiaceae	Natural	S, MM, HM	C
379	*Xylosma longifolium*	N	Flacourtiaceae	Natural	T, S, MM	E//W
380	*Zizyphus incurva*	N	Rhamnaceae	Natural	S, MM	E/C

Appendix E

Priority Species

Species	Tree or other	Native (N) or exotic	Reasons for priority	Physiographic regions
Abies pindrow	T	N	Economic	HM, MM
Abies spectabilis	T	N	Economic	HM, MM
Acer caesium	T	N	Economic	HM, MM
Acer oblongum	T	N	Economic	HM
Acrocarpus fraxinifolius	T	N	Economic	T,S
Aesculus indica	T	N	Economic	MM
Aesandra butyracea	T	N	Economic	MM,S
Albizia lebbeck	T	N	Economic	T, S
Albizia procera	T	N	Economic	T,S
Alnus nepalensis	T	N	Economic	MM,HM
Artocarpus heterophyllus	T	N	Economic	T,S
Anogeissus latifolia	T	N	Economic	T, S
Anthocephalus chinensis	T	N	Economic	T,S
Artocarpus lakoocha	T	N	Economic	MM,S
Azadirachta indica	T	N	Economic/ social	T, S
Bamboo spp.	T	N	Economic	T, S,M
Bauhinia purpurea	T	N	Economic	MM
Bauhinia variegata	T	N	Economic	MM
Betula alnoides	T	N	Economic	HM,MM
Betula utilis	T	N	Economic	HM,MM
Boehmeria rugulosa	T	N	Economic	MM,S
Bombax ceiba	T	N	Economic	T,S
Brassaiopsis hainla	T	N	Economic	MM
Bridelia retusa	T	N	Economic	MM,S
Castanopsis spp.	T	N	Economic	MM
Cedrus deodara	T	N	Economic	MM, HM
Cryptomeria japonica	T	E	Economic	MM, HM
Calamus spp.	Shrub	N	Economic	T,S
Cupressus torulosa	T	N	Economic	MM
Dalbegia sissoo	T	N	Economic	T,S
Dalbergai latifolia	T	N	Threatened	T,S
Dendrocalamus spp.	Shrub	N	Economic	T,S,MM
Eucalyptus camaldulensis	T	E	Economic	T,S
Phyllanthus emblica	T	N	Economic	T,S
Ficus roxburghii	T	N	Economic	MM,HM,S,T
Ficus hispida	T	N	Economic	MM,HM,S,T
Ficus lacor	T	N	Economic	MM,HM,S,T
Juglans regia	T	N	Economic	MM,HM
Juniperus spp.	T	N	Social and cultural	T,S

Lagerstroemia parviflora	T	N	Economic	T,S
Melia Azedarach	T	N	Economic	T,S,MM
Michelia spp.	T	N	Economic	MM,S,T
Morus alba	T	N	Economic	T,S
Myrica esculanta	T	N	Economic	MM,S
Pterocarpus marsupium	T	N	Threatened	T,S
Pinus patula	T	E	Economic	MM, HM
Pinus roxburghii	T	N	Economic	S, MM
Populus cilliata	T	E	Economic	T,S
Populus deltoides	T	N	Economic	HM,HH
Prunus cerasoides	T	N	Economic	MM
Quercus spp.	T	N	Economic	MM,HM
Schima wallichii	T	N	Economic	MM,S
Rhododendron spp.	T	N	Economic, social and cultural	HM
Shorea robusta	T	N	Economic	T,S
Syzygium cumini	T	N	Social	T,S
Sapindus mukorossi	T	N	Economic	MM,S
Taxus wallichiana	T	N	Economic	MM, HM
Tectona grandis	T	E	Economic	T,S
Terminalia chebula	T	N	Social	T,S
Toona ciliata	T	N	Economic	MM

Note; T=Tarai, S=Siwaliks, MM=Middle Mountain, HM=High Mountain, HH= High Himalaya.

Appendix F

Tree and other woody species those are actively managed for human utilization in the country

Species	Native (N) or Exotic (E)	Current uses (based on relative importance)	Type of management system	Physiographic zones
Acacia catechu	N	T, F, Ag	Natural and farm	T, S
Acacia nilotica	E	Fo, F, T, Ext, Ag	Natural and plantation	T,S
Acer oblongum	N	T, Fo	Natural	HM
Adina cordifolia	N	T, Fo	Natural	T,S
Aegle marmelos	N	Fr,Ag	Natural	T, S
Aesandra butyracea	N	F, Fo,Ex	Natural	MM
Ailanthus excelsa	E	Fo, T	Natural	T
Albizia chinensis	N	Fo, T, F, Ag	Natural	T,S
Albizia lebbeck	N	T,F, Fo, Ag	Natural	T,S
Albizia procera	N	Fo, Ag	Natural	T,S
Alnus nepalensis	N	F, Fo, T,Ag	Natural and plantation	MM,HM
Anogeissus latifolius	N	F, T, Fo	Natural	T,S
Anthocephalus chinensis	N	T, P, Fo	Natural	T,S
Antidesma diandrum	N	Fr, Fo	Natural, Farm	
Artocarpus lakoocha	N	Fo, F, Ag, Fr	Farm	MM
Azadirachta indica	N	Ex, F, Fo, T,Ag	Farm	T,S
Bassia butyracea	N	Fr, Fo,Ag	Natural, Farm	MM,S
Bassia latifolia	N	T, F, Ag	Natural, Farm	T,S
Bauhinia purpurea	N	Fo, food, F,Ag	Natural	MM,S,T
Bauhinia variegata	N	Fo, Ag, F, Fr	Natural	MM,S,T
*Betula alnoides**	N	F, Fo, T	Natural	HM,MM
Betula utilis	N	T, Fo, M	Natural	HM,MM
Boehmeria rugulosa	N	Fo	Natural	MM
Bombax ceiba	N	T, F, Pl	Natural	T,S
Brassaiopsis glomerulata	N	Fo, Ag	Natural	MM
Brassiopsis hainla	N	Fo, Ag	Natural	MM
Bridelia retusa	N	Fo, Ag	Natural	MM
Butea monosperma	N	Fo	Natural	T,S
Callicarpa arborea	N	Fo, F, Ag		
Cassia fistula	N	F, T,	Natural	T,S
Cassia siamea	N	Fo, Ag	Natural	T,S
Castanopsis indica	N	Fo, Fr,T, Ag	Natural	MM
Castanopsis tribuloides	N	F, Fo	Natural	MM

Celtis australis	N	Fo	Natural	MM,HM
Choerospondias axillaris	N	Fr, Fo	Farm	MM
Cinnamomum camphora	E	T, Ex	Natural	S,MM
Cinnamomum glaucescens	N	Fo	Natural	S,MM
Cinnamomum tamala	N	T, Ex	Natural	S,MM
Cordia dichotoma	N	Fo	Natural	T,S,MM
Crateava religiosa	N	Fo	Natural	
Cryptomeria japonica	E	Fo,T	Natural	MM
Dalbergia latifolia	N	T	Natural	T,S
Dalbergia sissoo	N	T, F, Fo, Ag	Natural and plantation	T,S
Daphne bholua	N	P	Natural	MM
Dendrocalamus hamiltonii	N	Fo	Natural	T,S
Dendrocalamus strictus	N	Fo, P	Natural	T,S
Diospyrus melanoxylon	N	F	Natural	T, S
Engelhardtia spicata	N	F,T	Natural	MM
Erythrina stricta	N	Fo, F, Ag	Natural	T,S
Eucalyptus camaldulensis	N	F, P, M, Ag	Natural	T
Ficus auriculata	N	Fo,Ag	Farm	T, S,MM
Ficus bengalensis	N	Fo,Ag	Natural	T
Ficus glaberrima	N	Fo	Natural	MM
Ficus glomerata	N	Fo,F, Ag	Natural	T, S,MM
Ficus hispida	N	Fo, Ag, F	Farm, natural	MM
Ficus lacor	N	Fo, F, Ag	Natural	S,MM
Ficus nemoralis	N	Fo, Ag	Natural	MM
Ficus neriifolia	N	Fo	Farm	MM,HM
Ficus semicordata	N	Fo, F, Fr, Ag	Farm	T,S,MM
Fraxinus floribunda	N	F, T, Ag	Farm	
Garuga pinnata	N	Fo, Ag, F	Natural	T,S
Gmelina arborea	N	T, Fo, F,P	Natural	T,S
Grewia optiva	N	Fo, T, F	Natural, Farm	T,S
Guazuma ulmifolia	E	Fo	Natural	T
Lagerstroemia parviflora	N	T, F, Fo,Ag	Natural	T,S
Leucaena diversifolia	N	Fo	Natural	T,S
Leucaena leucocephala	N	Fo, Ag, F	Natural	T,S
Litsea monopetala	N	Fo,F, Ag	Natural	T,S,MM
Lyonia ovalifolia	N	F	Natural, Farm	MM
Machilus spp.	N	Fo, F, Ag	Natural	MM
Mallotus philippensis	N	Fo, F, Ag	Natural	T,S
Mangifera indica	N	Fr, Fo	Farm	T,S
Melia azedarach	N	T, F, Fo, Ag	Natural	T,S
Michelia champaca	N	T, Fo, F	Natural	MM,HM
Michelia kisopa	N	Fo	Natural	MM

Morus alba	E	Fo, Ag, F, Fr	Farm	T,S
Myrica esculenta	N	Fr, Fo	Natural	MM,S
Phyllanthus emblica	N	Fr	Natural, Farm	T,S
Phyllanthus emblica	N	M, T, Fo	Natural	T,S
Pinus patula	N	Fo,Ag	Natural	MM,HM
Pinus roxburghii	N	T, F, Ag	Natural and plantation	S,MM
Pinus wallichiana	N	T, F	Natural	MM,HM
Populus ciliata	N	Fo	Natural and plantation	HM
Premna integrifolia	N	Fo, Ag	Natural	T,S
Premna latifolia	N	Fo, F, Ag	Natural, Farm	MM, S
Prunus cerasoides	N	Fo, F, T, Ag	Natural, Farm	MM,HM
Pterocarpus marsipium	N	Fo	Natural	T
Pyrus pashia	N	F, Fr	Natural	MM,HM
Quercus spp.	N	Fo,T, F	Natural	MM,HM
Randia dumetorum	N	Fr	Natural	T,S
Rhus javanica	N	Fo, F, Fr, Ag	Natural	MM
Salix spp.	N	Fo, F, Ag	Farm	MM
Sapindus mukorossi	N	T, Fr	Natural	MM,S
Saurauia napaulensis	N	Fo	Farm	MM,HM
Schima wallichii	N	Fo, F, T	Natural	MM,S
Sesbania grandiflora	N	Fo, F, Ag	Natural	T,S
Shorea robusta	N	T, F, Fo	Natural	T,S
Sterculia villosa	N	T	Natural	MM
Syzygium cumini	N	T, Fo, Fr	Natural	T,S
Tamarindus indica	N	Fr,T, F	Natural	T
Taxus wallichiana	N	Fo	Natural	MM,HM
Tectona grandis	E	T, F	Plantation	T,S
Terminalia alata	N	T, F, Fo	Natural	T,S
Terminalia belerica	N	Fo,Ag	Natural	T,S
Terminalia chebula	N	Fo	Natural	T,S, MM
Toona ciliata	N	T,Fo, Ag	Natural	MM
Zizyphus jujuba	N	F, Fo, Fr	Natural	T,S

Current use:

1. Solid wood products (T)
2. Pulp and paper (P)
3. Energy (fuel) (F)
4. Non wood forest products (food, fodder, medicine, etc.)(Fo)
5. Used in agro forestry systems (Ag)
6. Other (please specify), Fruit (Fr), Extractives (Ex), Ply wood (Pl)

Appendix G

Main tree and other woody species providing environmental services or social values

SN	**Species**	**Native (N) or Exotic (E)**	**Environmental service or social value (code)**	**Physiographic zone**
3	*Acacia arabica*	E	SW	T
1	*Acacia catechu*	N	SW, R	T,S
2	*Acacia pennata*	N	SW	T
4	*Aegle marmelos*	N	R	T,S
5	*Albizia julibrissin*	N	SW	T,S, MM
6	*Albizia lebbeck*	N	SW,S	T, S
7	*Albizia procera*	N	SW,S	T,S
8	*Alnus nepalensis*	N	SW,S	MM,HM
9	*Anthocephalus cadamba*	N	R	T,S
10	*Areca catechu*	N	R	T
11	*Artocarpus integrifolia*	N	R	MM
12	*Artocarpus lakoocha*	N	SW	MM
14	*Bambusa balcooa*	N	SW	T, S,MM
15	*Bassia butyracea*	N	R, SW	MM,HM
16	*Bauhinia purpurea*	N	SW	MM, S, T
17	*Bauhinia veriegata*	N	SW	MM, S,T
18	*Brassaiopisi hainla*	N	SW	MM
13	*Butea monosperma*	N	R	T,S
19	*Casuarina equisetifolia*	E	SW	T, S
20	*Choerospondias axillaris*	N	SW	MM
21	*Cinnamomum camphora*	N	R	S, MM
23	*Cuauchun cuesicultion*	N	R	T
24	*Dalbergia sissoo*	N	SW	T,S
25	*Elaeocarpus sphaericus*	N	R	T,S
27	*Phyllanthus emblica*	N	SW	T,S
26	*Erythrina arborescenes*	N	SW	T, S
28	*Erythrina stricta*	N	R, SW	T,S
30	*F. benjamina*	N	R	MM
31	*F. glaberrima*	N	R, SW	MM
32	*F. glomerata*	N	R	T,S,MM
33	*F. lacor*	N	R, SW	S, MM
34	*F. religiosa*	N	R,SW	T,S
29	*Ficus bengalensis*	N	R	T

35	*Ficus roxburghii*	N	SW	MM
36	*Ficus semicordata*	N	SW	T,S,MM
37	*Fraxinus floribunda*	N	SW	MM
38	*Garunga pinnata*	N	SW	T,S
39	*Grewia oppositifolia*	N	SW	T,S,MM
40	*Juglans regia*	N	R	T,S
41	*Leucaena leucocephala*	E	S, SW	T,S
42	*Litsea monopetala*	N	SW	T,S,MM
44	*Mangifera indica*	N	R	T,S
45	*Melia azedarach*	N	SW	T,S
47	*Mesua ferrea*	N	R	T,S
46	*Michelia champaca*	N	SW	MM,HM
43	*Morus alba*	E	S,SW	T,S
48	*Phyllanthus emblica*	N	R	T,S
49	*Pinus roburghii*	N	SW, R	S, MM
50	*Pinus wallichiana*	N	SW, R	MM
51	*Populus deltoides*	E	SW	T
52	*Prunnus cerasoides*	N	R, SW	MM,HM
53	*Pterocarpus marsupium*	N	R	T
54	*Rhododendron arboreum*	N	R,SW	MM, HM
55	*Rhus succedanea*	N	R	MM
56	*Salix tetrasperma*	N	R, SW	MM
57	*Santalum album*	N	R	T,S, MM
58	*Saraca indica*	N	R	T
59	*Saurauia nepaulensis*	N	SW	MM,HM
60	*Schima wallichii*	N	SW	MM
61	*Sesbania grandiflora*	N	S, SW	T,S
62	*Shorea robusta*	N	R	T,S
63	*Terminalia alata*	N	R	T,S
64	*Terminalia chebula*	N	R	T,S
65	*Vitex negundo*	N	SW	T,S

Note; T=Tarai, S=Siwaliks, MM=Middle Mountain, HM=High Mountain, HH= High Himalaya.

Services and values include:

1. Soil and water conservation including watershed management (SW)
2. Soil fertility (S)
3. Biodiversity conservation (B)
4. Cultural values (C)
5. Aesthetic values (A)
6. Religious values (R)

Appendix H
Eco–regions of Nepal

SN	Eco-regions	Altitude (m)	Comparision index
1	Eastern Himalayan alpine shrub and meadows	1822-8038	4.18
2	Eastern Himalayan broadleaf forests	270-4707	0.27
3	Eastern Himalayan sub-alpine conifer forests	795-6324	2.40
4	Himalayan sub-tropical broadleaf forest	80-2245	0.40
5	Himalayan sub-tropical pine forests	249-3724	0.18
6	Lower Gangetic Plains moist deciduous forests	58-92	Not represented
7	Rock and ice	2375-8808	3.86
8	Tarai-Duar savanna and grasslands	58-999	0.56
9	Upper gangetic Plains moist deciduous fores	120-164	Not represented
10	Western Himalayan alpine shrub and meadows	1631-8132	1.53
11	Western Himalayan broadleaf forests	486-4236	0.73
12	Western Himalayan subalpine conifer forests	1082-4457	0.42

Appendix I

Forest and Ecosystem diversity in PAs of Nepal

Protected Areas	Forest type diversity	Ecosystem Diversity
1. Koshi Tappu WR	6231 Lower Tropical Sal and Mixed Broad leaved Forest	7202 Khair-sissoo riverian Forest 7206 Pseudo steppe with Graminae, Tropical Elephant grasses 9000 Cultivated land 9002 Tarai cultivated areas 9900 Water bodies
2. Langtang NP	2101 Upper Alpine Meadow 2211 Dry Alpine Scrubs 2231 Moist Alpine Scrubs 3001 Trans Himalayan Steppe 3131 Birch-Rhododendron Forest 3211 Fir Forest 3212 Larch Forest 4131 Temperate Mountain Oak Forest 4221 Mixed Blue Pine-Oak Forest 4231 Lower Temperate Oak Forest 4235 East Himalayan Oak-Laurel Forest 5021 Chir Pine-Broadleaved Forest 5033 *Schima-Castanopsis* Forest 6131 Hill Sal Forest	1000 Glacier, snow, rock 2108 Meadows; mat patches 2110 Meadows and common land 2202 Rhododendron mesohygrophytic scrublands (Rhododendron. *anthopogon, R. nivale*) 2203 Juniper mesohygrophytic scrublands (*Juniper indica, J. recurva, J. squamata*) 3102 Rhododendron - Birch forest (*Betula utilis, R. campanulatum*) 3121 Rhododendron Shrublands 3203 Fir forest (*Abies spectabilis*) 3222 *Larix griffithiana, L. potanini* Forest 4004 Open and dry montane Blue Pine Forest 4009 Mountain Oak forest (*Quercus semecarpifolia*) 4021 *Rhododendron cinnamoeum* Forest 5008 Collinean Oak-mixed broadleaved forest (*Q.lanata*) 5010 Deciduous broad-leaved forest (*Alnus, Juglans*, Acer) 5015 Mesohygrophytic forest with *Quercus lanata, Pinus excelsa* 6220 *Schima wallichii, Castanopsis indica* hygrophile Forest 6221 *Schima wallichii, Pinus roxburghii* mesohygrophyle Forest 6222 *Pinus roxburghii* xerophile forest with *Phyllanthus emblica*

3. Suklaphanta WR	5011 Chir Pine forest 6131 Hill Sal forests 6231 Lower tropical Sal and Mixed Broad leafed forest	7201 Tarai tropical Sal forest (*Shorea robusta, Terminalia tomentosa)* 7202 Khair-sissoo riverian Forest 9002 Tarai cultivated areas
4. Parsa Wildlife Reserve	6131 Hill Sal forest 6231 Lower tropical Sal and Mixed Broad leafed forest	7101 Tropical hill Sal forest in large valleys 7103 Sal forest in inner valleys (*Shorea robusta, Terminalia tomentosa*) 7105 Hygrophytic tropical forest on northern slopes of the Siwaliks 7121 Tropical riverain Forest 7202 Khair-sissoo riverian Forest 7206 Pseudo steppe with Graminae, 7220 Tarai tropical Sal Forest 7222 Tropical dense forest with Terminalia
5. Sagarmatha National Park	2101 Upper Alpine Meadow 2211 Dry Alpine Scrubs 2231 Moist Alpine Scrubs 3131 Birch-Rhododendron Forest 3211 Fir Forest 4111 Upper Temperate Blue Pine Forest 4131 Temperate Mountain Oak Forest 4231 Lower Temperate Oak Forest	1000 Glacier, snow, rock 2101 Alpine meadow with Graminae and Cyperacea 2108 Meadows; mat patches 2109 Sparsely vegetated rocks and screes of upper alpine level 2110 Meadows and common land 2203 Juniper mesohygrophytic scrublands (*Juniperus indica, J. recurva, J. squamata*) 3120 *Betula utilis* forest *Rhododdendron* & *Abies spectablis* 4004 Open and dry montane Blue Pine Forest 4006 Juniper Forest

6. Shey-Phoksundo National Park	2211 Dry alpine Scrub 2231 Moist Alpine Scrub 3001 Trans- Himalayan Steppe 3002 Trans Himalayan Lower *Caragana* Steppe 3003 Trans Himalayan High Alpine 3231 Sub Alpine Mountain Oak Forest 4111 Upper Temperate Blue Pine Forest 4114 Spruce Forest 4212 Cedar Forest 4213 Cypress Forest	1000 Glacier, snow, rock 2102 Xerophytic mat patches and scarcely vegetated on rocks 2201 Rhododendron mesohygrophytic scrublands, juniperus… meadow 2204 Xerophytic closed alpine mat and scrub 3102 Rhododendron - Birch forest (*Betula utilis, Rhododendron campanulatum*) 3103 Birch-Blue pine open Forest 3203 Fir forest (*Abies spectabilis*) 4004 Open and dry montane Blue Pine Forest 4006 Juniper forest(*Juniperus indica*) 4009 Mountain Oak forest(*Quercus semecarpifolia*) 5001 Cypress forest with dwarf Barberry 5006 Cedar Forest 5009 Aesculus, Juglans riverain Forest 6201 Chir-Pine forest with grasses and Engelhardtia 6207 Grasses-Artemisia steppe 8001 High altitude cushion plant formation 8003 *Caragana geradiana, Lonicera spinosa* xerophile steppe 8004 *Caragana brevispina*, Artemisia steppe 8005 *Caragana pygmaea, Lonicera spinosa,* xerophile steppe 8006 *Myricaria-Hippophae-Salix* reverain thickets 9900 Water bodies
7. Rara National Park	2231 Moist Alpine Scrubs 3131 Birch-Rhododendron Forest 3211 Fir Forest 3231 Sub-alpine Mountain Oak Forest 4111 Upper Temperate Blue Pine Forest 4114 Spruce Forest 4213 Cypress Forest 4231 Lower Temperate Oak Forest 4233 Lower Temperate Oak Forest 5021 Chir Pine-Broadleaved Forest	2104 Mesophytic and hydrophytic mat patches on rocks 3102 Rhododendron-Birch forest (*Betula utilis, Rhododendron campanulatum*) 3203 Fir Forest (*Abies spectabilis*) 4002 Mixed Blue Pine-Oak Forest 4004 Open and dry montane Blue Pine Forest 4005 Blue Pine-Spruce Forest 4006 Juniper forest(*Juniperus indica*) 4009 Mountain Oak forest (*Quercus semecarpifolia*) 5010 Deciduous broad-leaved Forest (Alnus, Juglans, Acer) 6203 *Alnus nepalensis* riverain Forest 9900 Water bodies

8. Makalu-Barun National Parks	2101 Upper Alpine Meadows 2231 Moist Alpine Scrub 3131 Birch Rhododendron Forest 3211 Fir Forest 4131 Temperate Mountain Oak Forest 4135 Deciduous Maple-*Magnolia-Sorbus* Forest 4136 Mixed Rhododendron–Maple Forest 4231 Lower Temperate Oak Forest 4235 East Himalayan Oak-Laurel Forest 5021 Chir Pine broadleaved Forest 5033 *Schima-Castanopsis* Forest 6131 Hill Sal Forest	1000 Glacier, snow, rock 2101 Alpine meadow with Graminae and Cyperacea 2201 Rhododendron mesohygrophytic scrublands, juniperus… meadows 2202 Rhododendron mesohygrophytic scrublands (*Rhododendron anthopogon, R. nivale*) 2206 Shrubland with patches of abundant *Rhododendron anthopogon*, R. nivale 3102 Rhododendron-Birch forest (*Betula utilis, R. campanulatum*) 3120 *Betula utilis* forest Rhododdendron & *Abies spectablis* 3121 Rhododendron Shrublands 3122 Rhododendron-juniper shrublands 3203 Fir forest (Abies spectabilis) 3220 *Abies spectabilis* forest with *Rhododendron* 4009 Mountain Oak forest(*Quercus semecarpifolia*) 4022 Deciduous mixed broad-leaved Forest 4023 Mixed broadleaved forest, Rhododendron-Acer-Symplocos-Lauraceae 4024 *Daphniphyllum himalayense* 5008 Collinean Oak-mixed broadleaved Forest (*Qeurcus lanata*) 5010 Deciduous broad-leaved forest (*Alnus, Juglans*) 6109 Hygrophytic *Schima wallichii, Castanopsis tribuloides* Forest 6220 *Schima wallichii, Castanopsis indica* hygrophile Forest 6221 *Schima wallichii, Pinus roxburghii* mesohygrophyle Forest 7101 Tropical Hill Sal forest in inner valleys
9. Khaptad National Park		3201 Mesophytic Fir forest with oak and rhododendron 4001 Mesophytic montane Oak-Rhododendron Forest 4003 Mixed hygrophytic Oak-Hemlock-Fir Forest 5002 Collinian Oak forests 5003 Mixed Oaks-Laurel Forests 6101 Mixed Chir Pine-Oak Forests 6201 Chir Pine forest with grasses and *Engelhardtia* 6203 *Alnus nepalensis* Riverine Forests
10. Kangchenjung	2101 Upper Alpine Meadow	1000 Glacier, snow, rock

a Conservation Area	2231 Moist Alpine Scrub 3211 Fir Forest 3212 Larch Forest 4136 Mixed Rhododendron Maple Forest 4235 Deciduous Maple Magnolia *Sorbus* Forest 5033 *Schima Castanopsis* Forest 6131 Hill Sal Forest	2101 Alpine meadow with Graminae and Cyperacea 2202 Rhododendron mesohygrophytic scrublands (*Rhododendron anthopogon, R. nivale*) 2206 Shrubland with patches of abundant *Rhododendron anthopogon, R. nivale* 3220 Abies spectabilis forest with rhododendron 3221 Larix griffithiana Forest 4008 Hemlockforest(Tsuga dumosa) 4023 Mixed broadleaved forest, Rhododendron-Acer-Symplocos-Lauraceae 5012 Hygrophytic forest with *Quercus lamellosa* 6110 *Castanopsis tribuloides* forest with *Schima wallichii*… 6220 Schima wallichii, Castanopsis indica hygrophile Forest
11. Bardia National Parks	5011 Chir Pine Forest 6131 Hill Sal Forest 6231 Lower Tropical Sal and Mixed Broadleaved Forest	6104 Upper Siwaliks Chir Pine Oak Forest 6205 Siwaliks Chir Pine Forest 7101 Tropical hill Sal forest in large valleys 7201 Tarai tropical Sal forest (*Shorea robusta*, *Terminalia tomentosa*…) 7202 *Khair-sissoo* riverian Forest 7205 Bhabaar light Sal Forest 9002 Tarai cultivated land
12. Chitwan National Park	6131 Hill Sal Forest 6231 Lower Tropical Sal and Mixed Broad leafed Forest	7101 Tropical hill Sal Forest 7103 Sal Forest 7121 Tropical riverain Forest 7202 Khair-Sissoo riverain Forest 7206 Pseudo steppe with Graminae 7220 Tarai tropical Sal Forest 9002 Tarai cultivated land
13. Dhorpatan Hunting reserve	2101 Upper Alpine Meadows 2231 Moist Alpine Scrubs 3003 Trans-Himalayan High Alpine Vegetation 3131 Birch-Rhododendron Forest 3211 Fir Forest 4112 Temperate Juniper Forest 4131 Temperate Mountain Oak Forest	1000 Glacier, snow, rock 2103 Mesophytic mat patches and scarcely vegetated rocks and screes 2201 Rhododendron mesohygrophytic scrublands, juniperus… meadows 3102 Rhododendron - Birch forest (*Betula utilis, R. campanulatum*) 3203 Fir forest (*Abies spectabilis*) 4002 Mixed Blue Pine-Oak Forest

	4231 Lower Temperate Oak Forest 4233 Deciduous Walnut-Maple-Alder Forest 5021 Chir Pine-Broadleaved Forest	4006 Juniper forest (*Juniperus indica*) 4009 Mountain Oak forest (*Quercus senecarpifolia*) 5002 Collinean Oak forest *(Quercus leucotrichophora, Q.lanata*) 5009 Aesculus, Juglans riverain Forest 5011 Hygrophytic *Quercus lamellosa* Forest 6101 Mixed Chir-Pine Oak Forest 6204 Euphorbia royleana steppe in inner valleys 8001 High altitude cushion plant formation
14. Manaslu Conservation Area	2101 Upper alpine Meadow 2231 Moist Alpine Scrub 3001 Trans Himalayan Steppe 3003 Trans Himalayan High Alpine 3131 Birch –Rhododendron Forest 3212 Fir Forest 4111 Upper Temperate Blue Pine forest 4131 Temperate Mountain Oak Forest 4231 Lower Temperate Oak forest 5021 Chir Pine and Broad-leaved Forest	1000 Glacier, rock, snow 2101 Alpine meadow with Gramineae and Cyperaceae 2103 Mesophytic mat patches and vegetation on rocks 2105 Alpine meadows on the southern side of the Himalaya 2201 Rhododendron mesohygrophytic scrublands 3102 Upper sub alpine rhododendron-birch Forest 3103 Upper sub alpine birch bluepine open Forest 3110 Upper sub alpine north Himalayan Forest 3203 Lower sub alpine fir Forest 4004 Open and dry montane blue pine 4006 Juniper Forest 4007 Rhododendron oak hemlock Forest 4009 Mountain *Quercus semicarpiflora* Forest 4010 Blue pine spruce Forest 4011 Spruce mountain Forest 5011 Hygrophytic Q lamelosa Forest 6109 Hygrophytic Schima castanopsis 6210 Engelhardtia forests (Upper subtropical) 6210 Hygrophytic Schima castanopsis Engelhardtia forests (Lower subtropical) 8001 High altitude cushion plant formation
15. Shivapuri National Park	4131 Temperate mountain oak Forest 4235 East Himalayan oak laurel Forest 5021 Chir pine and broad leaved Forest 5033 Schima castanopsis Forest	4009 Mountain Oak (*Quercus semecarpifolia*) Forests 5008 *Collinean* Oak-mixed broad leaved Forests 6220 *Schima- castanopsis* hygrophytic Forests 6221 Schima wallichii, *Pinus roxburghii,* mesohygrophile Forests 6222 *Pinus roxburghii* xerophile Forests
16. Annapurna Conservation	2101 Upper Alpine Meadows 2231 Moist Alpine Scrubs	1000 Glacier, snow, rock 2103 Mesophytic mat patches on rocks

Area	3001 Trans-Himalayan Upper *Caragana* Steppe 3002 Trans-Himalayan Lower *Caragana* Steppe 3003 Trans-Himalayan High Alpine Vegetation 3111 Fir-Blue Pine Forest 3211 Fir Forest 4111 Upper Temperate Blue Pine Forest 4114 Spruce Forest 4213 Cypress Forest 4221 Mixed Blue Pine-Oak Forest 4231 Lower Temperate Oak Forest 4235 Lower Temperate Oak Forest 5033 *Schima-Castanopsis* Forest 6131 Hill Sal Forest	2104 Mesophytic and hydrophytic mat patches and scarcely vegetated 2201 Rhododendron mesohygrophytic scrublands, juniperus… meadows 3102 Rhododendron - Birch forest (*Betula utilis, Rhododendron campanulatum*) 3103 Birch - Blue pine open Forest 3110 North Himalayan alpine vegetation 3203 Fir Forest 8001 High altitude cushion plant formation 8002 Caragana versicolor, Lonicera spinosa steppe 8003 Caragana geradiana, Lonicera spinosa xerophile steppe 8004 Caragana brevispina, Artemisia steppe 8006 Myricaria-Hippophae-Salix reverain thickets 8007 Sophora moorcroftiana, Oxytropis mollis steppe 4003 Mixed hygrophytic Oak-Hemlock -Fir forest 4004 Open and dry montane Blue Pine Forest 4006 Juniper forest(Juniperus indica) 4009 Mountain Oak forest(Quercus semecarpifolia) 4010 Blue Pine-Spruce-Fir Forest 4011 Spruce mountain Forest (*Picea smithiana*) 5000 BluePine-Cypress Forest 5001 Cypress foerst with dwarf barberry 5007 Open Blue Pine forest(*Pinus wallichiana*) 5008 Collinean Oak-mixed broadleaved forest (*Quercus lanata*) 5009 Aesculus, Juglans riverain Forest 5011 Hygrophytic *Quercus lamellosa* Forest 6110 Castanopsis tribuloides forest with *Schima wallichii* 6220 *Schima wallichii*, *Castanopsis indica* hygrophile Forest 9003 Pokhara cultivated areas
17. Gaurisankar Conservation area	5011 Chir Pine Forest 5033 *Schima-Castanopsis* Forest 4111 Upper temperate blue pine forest 4221 Mixed Blue pine-Oak forest 4133 Rhododendron Forest 4231 Lower Temperate Oak Forest	Detail survey has not been carried out yet

	4136 Mixed Rhododendron-Maple Forest 4122 West Himalayan Fir-Hemlock-Oak Forest 4135 Deciduous Maple-*Magnolia-Sorbus* Forest 4131 Temperate Mountain Oak Forest 4235 East Himalayan Oak-Laurel Forest 4112 Temperate Juniper Forest 2231 Moist Alpine Scrubs	
18. Banke National Park	6231 Lower Tropical Sal and Mixed Broad leafed forest • Terminalia Forest • *Dalbergia sissoo-Acacia catechu* Forest • *Savannah/grass land* 6131 Hill Sal Forest 5021 Chir Pine Broadleaved Forest	Detail survey has not been carried out yet
19. Black Buck Conservation Area	Short grasslands, abandoned cultivated land, forest land	Detail survey has not been carried out yet
20. Api Nampa Conservation area	6131 Hill Sal Forest 4231 Lower temperate Oak Forest 3131 Birch-Rhododendron Forest 3222 Fir-Hemlock–Oak Forest 4112 Temperate Juniper Forest 2211 Dry Alpine Scrubs	Detail survey has not been carried out yet

Sources: Bhuju et al.(2007), DNPWC (n.d.); DNPWC (2011); BPP (1996)

Appendix J

District Tree Seed Stands

S. N.	Dev. Region	Scientific name	District	Potential Planting zone	Location
1	Eastern	*Juniperus wallichiana*	Ilam		Pashupatinagar
2		*Artocarpus* spp.	Jhapa	Lower tropical	Jalthal
3		*Dalbergia sissoo*		Lower tropical	Kankai
4		*Dalbergia latifolia*	Morang	Lower tropical	NA
5		*Cinnamomum tamala*	Udayapur	Upper tropical	Rauta VDC
6		*Acacia catechu*	Siraha	Lower tropical	NA
7	Central	*Dalbergia sissoo*	Dhanusa	Lower tropical	Gobindapur-1
8		*Tectona grandis*		Lower tropical	Umaprempur-1
9		*Dalbergia sissoo*	Bara	Lower tropical	Saphai VDC
10		*Albizia procera*			Ratanpur VDC
11		*Acacia catechu*	Chitawan	Lower tropical	NA
12		*Bombax ceiba*			Ghatan - 1-3
13		*Pinus roxburghii*	Bhaktapur	Sub Tropical	Nagarkot-6
14		*Pinus roxburghii*	Dhading	Sub Tropical	Jayamung-8
15		*Pinus wallichiana*	Dolakha	Sub Tropical	Jiri-9
16		*Quercus semecarpifolia*			Jiri-1,2
17		*Pinus roxburghii*			Fasku-1
18		*Pinus roxburghii*			Bhimeshowor-6
19		*Pinus roxburghii*	Kathmandu	Sub Tropical	Golddhunga VDC
20		*Alnus nepalensis*			Nagarjun
21		*Schima wallichii*			Nagarjun
22		*Pinus roxburghii*			Nagarjun
23		*Pinus roxburghii*			Gokarna-9
24		*Pinus roxburghii*			Gokarna-9
25		*Alnus nepalensis*			Sitapaila
26		*Pinus patula*			Dachhinkali-5
27		*Pinus roxburghii*	Kavrepalanchok	Sub Tropical	Mithinkot-1
28		*Pinus patula*			Chaubas
29		*Pinus patula*			Chaubas
30		*Castanopsis indica*	Lalitpur	Sub Tropical	Bishankhu
31		*Quercus lanata*			Godawari-5
32		*Alnus nepalensis*			Fulchoki
33		*Quercus semecarpifolia*			Godawari-5
34		*Eucalyptus camaldulensis*	Mahottari	Lower tropical	Bardibas-5
35		*Pinus roxburghii*	Makawanpur	Upper Tropical	Lamidanda
36		*Pinus wallichiana*			Paldanda

37		*Quercus semecarpifolia*			Namatar-1,2
38		*Dalbergia sissoo*			Rapti, Hetauda
39		*Pinus wallichiana*			Daman Ban
40		*Quercus semecarpifolia*			Daman
41		*Schima wallichii*	Nuwakot	Sub Tropical	Madanpur-8
42		*Pinus roxburghii*			Bandevi
43		*Dalbergia sissoo*	Parsa	Lower tropical	Biruwaghathi
44		*Tectona grandis*			Belwa VDC-6
45		*Pinus roxburghii*	Ramechhap	Sub Tropical	Sunarpani-5
46		*Pinus roxburghii*			Ramechap-9
47		*Pinus roxburghii*			Bhalwajor-2
48		*Tectona grandis*	Sarlahi	Lower tropical	Bhaktpur-2
49		*Dalbergia sissoo*			Lalbandi-5
50		*Choerospondias axillaris*	Sindhupalchok	Temperate	Chakrapal
51		*Pinus roxburghii*			Thumpakher
52		*Juglans regia*			Lishakhu
53		*Ficus auriculata*			Haibung
54		*Pinus patula*			
55		*Alnus nepalensis*	Sindhuli	Sub Tropical	Majuwa
56	Western	*Pinus roxburghii*	Arghakhanchi	Sub Tropical	Khaharapakha
57		*Aesandra butyracea*			Dhundarepakha
58		*Aesandra butyracea*			Sandhikharkha
59		*Pinus wallichiana*	Baglung	Sub Tropical	Malika
60		*Alnus nepalensis*	Gorkha	Temperate	Prithvi N.M.P-1
61		*Schima wallichii*			Prithvi N.M.P-10
62		*Acacia catechu*	Kapilbastu	Lower tropical	Budhi-1
63		*Dalbergia sissoo*			Shivapur-1
64		*Dalbergia sissoo*			Jayanagar-2
65		*Azadirachta indica*			
66		*Schima wallichii*	Kaski	Sub Tropical	Sarankot-6
67		*Castanopsis indica*			Pumdi Bhiumdi-1
68		*Alnus nepalensis*			Pumdi Bhiumdi-2
69		*Quercus semecarpifolia*	Lamjung		Beshisher-4
70		*Alnus nepalensis*	Mygadi	Temperate	Patlekhet
71		*Michelia champaca*			Baramja VDC-6, Jhakrepani
72		*Dalbergia sissoo*	Nawalparasi	Lower tropical	Sunawal VDC-4
73		*Pinus roxburghii*	Palpa	Sub Tropical	Bhimsenthan-5
74		*Alnus nepalensis*			Tansen-10
75		*Aesandra butyracea*			Chahara-7
76		*Michelia champaca*			Kachal-2
77		*Pinus roxburghii*	Parbat		Durlung

78		*Tectona grandis*	Rupandehi	Lower tropical	Kothihawa-4
79		*Aesandra butyracea*	Shyanja	Sub Tropical	Pakawaudi
80		*Pinus roxburghii*			Seti dovan-9
81		*Castonapsis indica*			Palekoban
82		*Schima wallichii*			Gyan khola
83		*Castanopsis indica*	Tanahu	Sub Tropical	Bays-5
84		*Castonapsis indica*			Jamune-6
85		*Hippophae* spp.	Mustang	Sub Tropical	Lete- 4,5, Lete
86		*Pinus wallichiana*			Lete- 1,2,3., Ggasa
87		*Sapindus mukorossi*	Salyan	Sub Tropical	NA
88	Far-western	*Pinus roxburghii*	Baitadi	Sub Tropical	NA
89		*Pinus roxburghii*	Dadeldhura	Sub Tropical	Bhatkanda
90		*Quercus lanata*			Bhatkanda
91		*Dalbergia sissoo*	Kailali	Lower tropical	Godawari
92		*Syzygium cumini*			Debria

Note; NA= Not available.

Appendix K

Target forest species included within *in-situ* conservation programme

Species	Purpose of establishing conservation unit	Number of stands conserved	Total area (ha)
Acacia catechu	Seed	1	10.9
Albizia procera	Seed	1	NA
Alnus nepalensis	Seed	8	15.08
Anogeissus latifolia	Seed	2	3.6
Artocarpus spp.	Seed	1	NA
Azadirachta indica	Seed	1	NA
Bassia butyracea	Seed	4	10.3
Bombax ceiba	Seed	1	NA
Castanopsis indica	Seed	4	11.31
Choerospndias axllaris	Seed	1	10
Cinnamomum tamala	Seed	1	NA
Cordia dichotama	Seed	1	9
Cupressus torulosa	Seed	1	NA
Dalbergia latifolia	Gene conservation area	2	NA
Dalbergia sissoo	Seed	9	36.57
Eucalyptus camaldulensis	Seed	1	22
Ficus auriculata	Seed	1	NA
Hippophae rhamnoides	Seed and gene conservation area	1	1.5
Michelia champaca	Seed	1	10
Olea cuspidata	Seed	1	NA
Pinus petula	Seed	3	13.5
Pinus roxburghii	Seed	19	82.6
Pinus wallchiana	Seed	4	12.9
Pterocarpus marsupium	Gene conservation	2	NA
Pterocarpus santalinus	Seed	1	2.5
Qeurcus semecarpifolia	Seed	4	14.5
Sapindus mukorossi	Seed	1	NA
Schima wallichii	Seed	6	22.5
Tectona grandis	Seed	4	16.78
Zanthoxylum armatum	Seed	1	NA