THE STATE
OF THE WORLD's
FOREST GENETIC RESOURCES

COUNTRY REPORT

INDIA

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

INDIA

STATE OF FOREST GENETIC RESOURCES IN INDIA

A Country Report

Prepared by

Institute of Forest Genetics and Tree Breeding
(Indian Council of Forestry Research and Education)
Coimbatore

Ministry of Environment and Forests
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FOREWORD

Plant germplasm was once the common heritage of humanity, and there was free exchange of germplasm, their introduction to the areas beyond their natural distribution, their collection and storage in botanical gardens and use in many breeding programmes. As plant breeding became commercialized and there emerged the concept of breeders' rights, the issues concerning the quality of conservation of germplasm, security of the collections, ownership and control over the resources, inequitable nature of free access to genetic resources, role and recognition of traditional knowledge, etc., came to be debated. The major international developments that emerged as a result, affecting the conservation and use of genetic resources were the Convention on Biological Diversity (CBD), FAO's Global Plan of Action (GPA) for the conservation and sustainable utilization of Plant Genetic Resources for Food and Agriculture (PGFRA), International Treaty of Plant Genetic Resources for Food and Agriculture (IT-PGFRA) and the Trade-Related Aspects of Intellectual Property Rights System (TRIPS). These have led to a paradigm shift towards sovereignty of States over their genetic resources, leading to development of regulatory mechanisms.

India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats, species and their genetic diversity. The biodiversity in the forests is enormous, and is being used for socio-economic development, and the demand is increasing in view of the high economic growth. The sustained utilization of forests to meet present-day needs coupled with the protection of ecosystems and their functions provides the only solution for lasting, genetic conservation. Harmonizing conservation and management for the production of goods and services therefore gains importance in relation to the forest genetic resources.

Forest Genetic Resources management is a newly emerging multidisciplinary field dealing with collection, exchange, quarantine, biosafety, characterization, evaluation, conservation, documentation and sustainable use of plant germplasm from forests. This is proposed to be done using various technologies in conformity with the policies related to their access and benefit sharing, propriety and intellectual property issues through the National Bureau of Forest Genetic Resources (NBFGR) to be established. All this requires basically understanding the current state of forest genetic resources, their conservation and use.

In this context, the Commission on Genetic Resources for Food and Agriculture (CGRFA) of FAO acknowledged the urgency of conserving and sustainably utilizing forest genetic resources. With the support of the Committee on Forestry, the CGRFA decided that a State of the World's Forest Genetic Resources (SOW-FGR) report be prepared through a country-driven approach based on country reports. FAO is conducting this study and has requested member countries to submit their country reports

In a country like India with vast natural resources and diversity, the extent of effort required for FGR conservation is enormous in view of sustaining the productive values of forests, for maintaining the health and vitality of forest ecosystems and, for maintaining their protective and environmental roles. The forestry sector in India is impacted by various other sectors such as energy, agriculture, education, water resources, industry, infrastructure development, biofuels, change in demographic structure and high economic growth. Taking these factors into consideration, the country report has been prepared by IFGTB, Coimbatore, identified as the National Focal Point by the MoEF for FAO. The report has been developed after wide consultation with multi-stakeholders.

This country report focuses on the review of existing data and information. It has attempted identification of gaps and future needs in the area of FGRs. The document will serve as a strategic tool to guide national efforts to enhance the conservation and sustainable use of forest genetic resources in addition to providing information for the SOW-FGR. It will facilitate the Government of India and State Governments to make policy interventions for addressing future challenges in the conservation and management of the forest genetic resources.

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LIST OF ABBREVIATIONS USED

Abbreviation	Expanded form
ABS	Access and Benefit Sharing
AICP	All India Co-ordinated Programme
APFORGEN	Asia-Pacific Forest Genetic Resources Programme
AFRI	Arid Forest Research Institute
ADB	Asian Development Bank
BIS	Biodiversity information system
BGIR	Botanical Garden of Indian Republic
BSI	Botanical Survey of India
CSO	Clonal Seed Orchards
CGRFA	Commission on Genetic Resources for Food and Agriculture
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of fauna and flora
CPT	Candidate Plus Tree
CSIR	Council of Scientific and Industrial Research
CSIRO	Council For Scientific and Industrial Research, Australia
DANIDA	Danish International Development Agency
DFSC	DANIDA Forest Seed Centre
ESCAP	Economic and Social Commission for the Asia and the Pacific
ENVIS	Environmental Information System
EU	European Union
FORTIP	FAO Regional Forest Tree Improvement Project
FAO	Food and Agricultural Organization
FGR	Forest Genetic Resources
FGRMN	Forest Genetic Resources Management Network
FRM	Forest Reproductive Material
FRI	Forest Research Institute
FSI	Forest Survey of India
FREEP	Forestry Research, Education and Extension Project
FRIS	Forest resource information system
GPCA	Gene Pool Conservation Areas
GEF	Global Environment Facility
IBGN	Indian Botanical Garden Network
ICAR	Indian Council of Agriculture Research
ICFRE	Indian Council of Forestry Research and Education
IDPSTI	Indo-Danish Project on Seed Procurement and Tree Improvement
IFGTB	Institute of Forest Genetics and Tree Breeding
INBAR	International Network on Bamboo and Rattan
LEUCANET	International Network on *Leucaena* Research and Development
ITPGR	International Treaty on Plant Genetic Resources
ITTO	International Tropical Timber Organisation
JICA	Japan International Cooperation Agency
JFM	Joint forest management
LMMCs	Like Minded Megadiverse Countries
MFF	Mangroves for the Future
MTA	Material Transfer Agreement

MAI	Mean Annual Increment
MPCA	Medicinal Plant Conservation Area
MPDA	Medicinal Plants Development Area
NAPCC	National Action Plan on Climate Change
NBM	National Bamboo Mission
NBAP	National Biodiversity Action Plan
NBFGR	National Bureau of Forest Genetic Resources
NFAP	National Forestry Action Programme
NFRP	National Forestry Research Plan
NISM-GPA	National Information Sharing Mechanism on the implementation of the Global Plan of Action
NMPB	National Medicinal Plants Board
NMBA	National Mission on Bamboo Applications
NOVOD	National Oil Seeds and Vegetable Oil Development Board
NRCAF	National Research Centre for Agroforestry
NTSC	National Tree Seed Centre
NWAP	National Wildlife Action Plan
NTFP	non-timber forest-produce
PPP	Permanent Preservation Plots
PGRFA	Plant Genetic Resources for Food and Agriculture
PSIP	Planting Stock Improvement Programme
PA	Protected Areas
PPV & FRA	Protection of Plant varieties and Farmer's Rights Act
RFRI	Rain Forest Research Institute
REDD	Reduced Emissions from Deforestation and Forest Degradation
SG	Sacred Groves
SPA	Seed Production Areas
SSO	Seedling Seed Orchards
SAARC	South Asian Association for Regional Cooperation
SACEP	South Asian Cooperative Environmental Programme
SFD	State forest departments
SSC	State Seed Centre
TRIPS	Trade-Related aspects of Intellectual Property Rights
TKDL	Traditional Knowledge Digital Library
TBO	Tree Borne Oilseeds
TOF	Trees outside forests
TFRI	Tropical Forest Research Institute
UNCSD	United Nations Conference on Sustainable Development
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
VRC	Variety Release Committee
VMG	Vegetative Multiplication Gardens

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SECTION I

EXECUTIVE SUMMARY

Introduction to the country and the forest sector

India is the 7th largest country in the world with a land area of 3 287 263 sq.km. and the 2nd most populated country in the world with a population of 1 210 193 422 and an average population density of 382/sq.km. The recorded forests extend over 76.962 m ha forming 23.41% of the geographical area of the country. The forest and tree cover is 78.29 m ha accounting for 23.81% of the geographical area. India has 15.7 m ha of primary forests, 42.5 m ha of naturally regenerated forests and 10.25 m ha of planted forests. Much of the forests are public owned. The major forest types are sub-tropical dry deciduous, tropical moist deciduous, tropical thorn and tropical wet evergreen forests. In India area under forest cover has shown a decadal increase of 3.04 m ha between 2000 and 2010 registering an annual increase of 0.46%. India ranks 4th in term of the annual increase in planted forests, in the last 20 years registering an average increase of 0.25 m ha/year. The planted forests occupy 5% of the forest cover.

India is one of the 17 mega-diverse countries of the World and stands 8th in the world ranking of mega-biodiversity countries. It houses parts of four global biodiversity hotspots out of 34, which include the Eastern Himalayas, Indo-Burma, Western Ghats /Sri Lanka and a part of Sundaland in the Nicobar Islands.

The present management of the forestry sector is guided by the National Forest Policy of 1988, which made a paradigm shift from a focus on sustained timber yield to sustainable forest management. In the past decade, conservation and management of forests has been strengthened through various policy and legal frameworks, and the management of the natural forests is now oriented towards ecosystem services and addressing the livelihood of forest dwellers and forest fringe villages.

The domestic and industrial requirements of timber and other forest produce are met largely from the planted forests. The plantation area in India is 32.57 m ha which accounts for 17% of the global plantations and is the 2nd largest in the world after China. The growing stock of forests is estimated at 4 498.73 m m^3 and of the Trees Outside Forests (TOF) is 1 548.42m m^3. The estimated removal of wood from forests annually is 3.157m m^3 and from TOF is 42.77 m m^3. The TOF provide almost 80% of the wood requirement. The Mean Annual Increment (MAI) of the planted forests range from 10 to 60 m^3 /ha/yr; however the MAI of natural forests is just 0.5m^3/ha/yr as against the world average of about 2 m^3/ha/yr. This low productivity is mainly due to fire, grazing, over-exploitation and non-recycling of biomass in forest soil.

In spite of the low productivity and the continuously increasing demand, the forests continue to serve as source of timber, fodder, fuel wood, food, medicine and source of livelihood to a large number of forest dwellers and rural population. It is estimated that nearly 27% of the Indian population depends on forests for their livelihood. The annual consumption of wood in household construction and furniture, industries and agriculture is around 48 m m^3. Total annual consumption of fuel wood is estimated at 216.42 m tonnes, of which 58.75 m tonnes is extracted from forests. Major part of the fuel wood demand is absorbed by the TOF, but much of fuel wood is collected from the forests in an unorganized way and is an important factor impacting the growing stock and ecological balance. The non-timber forest-produce (NTFP) also contributes significantly to the economy accounting for 75% of India's exports of forest produce. Nearly 39% of cattle depend on forests for their fodder either partially or fully.

The requirement of wood and wood products is bound to increase in future, due to various economic and policy initiatives, related to education, infrastructure and housing. Wood requirement for meeting domestic energy requirement is expected to be stable, in view of switch over to non-wood sources of fuel.

For wood utilization there are about 23 000 sawmills, 950 units manufacturing wood based panels and veneer; 380 units producing pulp, paper and paper boards; 5 units of safety match and an unknown number of cottage match units. 90% of these units are in the small-scale. Most of these wood based industries are short of investment capital, hire unrecognized and legally unprotected labour, use outdated machinery and are characterized by poor management and technical skills. In timber trade, India is a net importer of forest products; the largest share occupied by logs, followed by paper and paperboards and recovered paper.

The main drivers of changes in the forestry sector are the demographic change, agriculture, infrastructure and industrial growth, urbanization, economic changes, climate change and the political and institutional environment. India's population is projected to touch 1.33 billion by 2020, at a growth rate of 1.38% per annum. The dependency of the population on forests is declining; however, the absolute size of the population dependent on forests would increase due to increase in population, and the demand for forest products would keep increasing. Agriculture remains the primary occupation for a majority in rural India, and with increasing focus on rainfed areas, diversification of agricultural practices and the new initiatives in agroforestry the TOF are likely to increase in future. The focus on small and medium industrial enterprises consuming a large proportion of forest products is likely to boost social forestry and farm forestry. The increasing urbanization and the growth of the Indian economy at the rate of 9% per annum puts pressure on environmental resources for physical infrastructure and consequently for wood based construction material and this would give a boost to agroforestry.

The forestry sector in India needs to gear up to deal with emerging demands and challenges. Increasing inter-sectoral linkages have to be understood. The use of modern technologies and concepts in natural resource management and compatible changes in governance and documentation systems, with accountability and transparency is the need of the hour.

The current state of forest genetic resources

The forests of India are classified into 16 major forest types and these forests house a wide array of species diversity. The documentation of species variation within the forests is done by the Botanical Survey of India (BSI). In terms of plant diversity India ranks 10th in the world and 4th in Asia. It is reported that 46 042 species of plants occur in India, representing 11% of world flora, of which

flowering plants account for 17 527 species. Of this 2 863 are trees that include some of the highly valued timbers of the world.

The survey of forest resources was initiated in 1965 with the project called the "Preinvestment Survey of Forest Resources" (PISFR), to ascertain the availability of raw material for establishment of wood based industries in selected areas of the country. Now it has been transformed into the Forest Survey of India (FSI) which prepares the State of Forest Report biennially, providing assessment of latest forest cover in the country and monitoring changes in these and also conducts inventory in forest and non-forest areas and develops database on forest tree resources. Since the study of specific variation itself is far from adequate, the studies on intraspecific variation are limited. The studies on genetic diversity are confined to a few economically important species that are under the process of domestication.

Based on the economic utility and conservation value, a large number of forest tree species have been prioritized for conservation and use, by the APFORGEN (Asia-Pacific Forest Genetic Resources Programme), the SFDs and recently in the 'Consultative Workshop on Strategies for Formulation of Forest Genetic Resources Management Network' held at the Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore in March 2011. Apart from this Indian Council of Forestry Research and Education (ICFRE) has identified important tree species for research under All India Co-ordinated Programme (AICP). While some of these species are extracted from the natural forests many are raised in the planted forests and agroforestry systems.

The degree of endemism in plant species is high in India. About 11 058 species are endemic to Indian region, of which 6 200 are flowering plants. As per IUCN Red List India has 246 globally threatened plant species, which is about 3% of the world's threatened plants. The BSI has also identified a large number of locally threatened species and regularly makes assessment of the threatened plant species including FGR. About 1 500 species of flowering plants and few hundreds of Pteridophytes, Bryophytes, Lichens and Fungi have been identified as threatened. After critical evaluation of their status and threat perceptions, data sheets on 1 182 species have been prepared out of which account of 708 species have already been published as Red Data Book of Indian Plants.

For about 130 species domestication and breeding efforts are in progress. The initiation of tree improvement programmes has been the reason for studying the intraspecific variation in many of the species. In these species, there is production and supply of Forest Reproductive Material (FRM), such as, the seeds, seedlings and ramets. Various SFDs, research organizations and universities have established Seed Production Areas, Clonal Seed Orchards, Seedling Seed Orchards, Vegetative Multiplication Gardens and modern nurseries for production of quality planting stock. Recently, attention towards improvement of fast growing native species and economically important indigenous species to support the TOF programme has become the priority.

A mechanism and monitoring body (Variety Release Committee) for release of clones/ varieties of forestry species has been evolved by the ICFRE. In species like Eucalypts, Casuarinas and Poplar, genetically improved elite clones have been released in the market. Simultaneously, DUS (Distinctness, Uniformity and Stability) descriptors have also been developed for species like Eucalyptus, Casuarina, Neem and Pungam as per the guidelines of Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV & FRA) to mark specific identity to clones and ensure authority over the clones developed.

To document forest reproductive material in the country, Certification of Forest Reproductive Material in India (Revised Scheme, 1979) was prescribed by the Government of India, but is not uniformly practiced in the absence of a legal backing to the scheme. Now the Forest Reproductive Material Certification Bill of 2008 is under consideration for enactment. At present the quantity of identified reproductive material used in forestry is negligible, and this is also one of the reasons for the low productivity.

The Government of India has plans to establish a National Bureau of Forest Genetic Resources (NBFGR) and as a precursor to that a Forest Genetic Resources Management Network (FGRMN) has been established in 2011 under ICFRE with its nodal centres at IFGTB, Coimbatore and Forest Research Institute (FRI), Dehradun. The FGRMN has been established with the objectives to plan, prioritize, organize, conduct and coordinate exploration, collection and documentation of indigenous and exotic forest genetic resources to strengthen *in situ* and *ex situ* conservation. It shall also undertake introduction, exchange and quarantine of genetic resources of forest origin. It shall characterize, evaluate and conserve forest genetic resources and ensure their sustainable management in collaboration with the user agencies. In this process a large number studies would be undertaken to understand the intraspecific diversity of the economically important species and those of conservation importance. The FGRMN will also be required to develop and maintain a national information network on FGR, develop molecular tools, techniques and approaches to characterize and validate the germplasm and conduct research, teaching and generation of public awareness on FGRs.

The state of *in situ* conservation

India has created a network of Protected Areas (PA) which includes 667 units (102 National Parks, 514 Wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves). Besides these there are 25 wetlands declared as Ramsar sites and 15 areas in different biogeographic zones declared as Biosphere Reserves. The extent of PA network is around 157 826.773 sq. km over 4.8 % of the land area. The National Wildlife Action Plan envisages increase of this to 10% of the land area. The conservation of biodiversity within the PA network takes care of the FGRs also.

In addition to the PAs, there are several other means of *in-situ* conservation like Sacred Groves (SG), Gene Pool Conservation Areas (GPCA), Medicinal Plant Conservation Areas (MPCA), Seed Production Area (SPA) and Permanent Preservation Plots (PPP). Sacred groves are patches of natural vegetation, which are protected through some religious faiths and exist throughout the country. They shelter many economically important, medicinal, endemic, rare and endangered species. There are about 309 preservation plots throughout the country, 187 in natural forests and 122 in plantations covering a total area of about 8 500 ha. Status of the preservation plots is monitored regularly for plant succession and crop dynamics. Efforts are on to establish more preservation plots. There are also a large number of plus trees located within the forest areas, which are preserved.

India is the 2nd richest country in bamboo genetic resources. Nearly 8 957 500 ha of forest area is occupied by bamboos. The main bamboo species are *Bambusa bambos, B. balcooa, B. pallida, B. tulda, B. polymorpha, Dendrocalamus hamiltonii, D. longispathus, D. strictus, Melocanna bambusoides, Oxytenanthera nigrociliata, O. parviflora, Pseudostachys polymorphium* and *Polystachya pergracile.* To promote the conservation and use of bamboos, India has launched the National Bamboo Mission (NBM) and the National Mission on Bamboo Applications (NMBA). A Bamboo Information Centre established at Kerala Forest Research Centre, Peechi disseminates

information on 137 species of Indian bamboo. There is a recently established Advanced Research Centre for Bamboo and Rattan at Aizawl, by the ICFRE.

Mangrove forests cover an area of 6 000 km^2, with 59 plant species under 41 genera and 29 families. The Government of India had launched a Scheme on Conservation and Management of Mangroves and Coral Reefs in 1986 for Conservation and protection of the mangrove ecosystem from further degradation; afforestation of degraded mangrove areas; maintenance of genetic diversity especially of the threatened and endemic species and creation of awareness among the people on importance of mangrove ecosystem and the need for its conservation. Under this programme 35 mangrove areas have been identified for intensive conservation and management. A National Mangrove Genetic Resource Centre has been established in Odisha, in the east coast of India, for conservation, afforestation and regeneration of mangrove species.

A National Medicinal Plants Board (NMPB) was established by Ministry of Health and Family Welfare for co-ordination and implementation of policies relating to conservation, harvesting, cultivation, research and marketing of medicinal plants through 32 State Medicinal Plant Boards. A network of 54 Medicinal Plant Conservation Areas (MPCAs) – as "forest gene bank sites" have been established which harbour 45% of recorded populations of flowering and medicinal plants of Peninsular India, including 70% of the red-listed species. To conserve wild germplasm, revitalize the indigenous health care and livelihood security a 'National Programme on Promoting Conservation of Medicinal Plants and Traditional Knowledge for enhancing Health and Livelihood Security' is under implementation.

The main constraint faced in *in- situ* conservation is the resistance to expansion of PA network, due to a general feeling that establishment of PAs leads to hardships to local communities, by restriction on access and use of resources inside PAs and increase in human-wildlife conflicts. More concerted efforts are required for the expansion of PA network. Linking the PAs into larger landscapes and also integrating the livelihood aspirations of local people in PA management is required. Ensuring up to date, site specific and scientific management planning of PAs, is a constraint which needs to be addressed through capacity building.

The state of *ex situ* conservation

More than 150 species are conserved *ex situ* with a focus on tree improvement and productivity and also species conservation. India has more than 100 botanical gardens under different management systems located in different bio-geographical regions, coming under the Indian Botanical Garden Network (IBGN). The Botanical Garden of Indian Republic (BGIR) has been established in 2002 as part of Botanical Survey of India by Ministry of Environment and Forests (MoEF). Assistance to Botanic Gardens and Centres has been given by MoEF since 1992 to augment *ex-situ* conservation of rare endemic plants. For conservation of medicinal plants, Medicinal Plants Development Area (MPDA) has been developed by the State Forest Departments.

There are ongoing long-term breeding programmes for a large number of species, including provenance trials, progeny trials, clonal trials, and seed orchards. Though these trials and seed orchards are established primarily for genetically improved seed, they are also put under selective conservation, as one of the objectives in *ex-situ* conservation. Germplasm banks and clone banks have also been established for many forest species. The germplasm in these banks are characterized for morphological characters for the purpose of identification and registration of clones and biochemical and physiological characters for the purpose of selection and breeding.

Thirty two medicinal plants have been identified as priority species for conservation and promotion of cultivation by NMPB, and 344 medicinal plants gardens have been established. National Oil Seeds and Vegetable Oil Development Board (NOVOD) set up by the Ministry of Agriculture for Integrated Development of Tree Borne Oilseeds (TBO) has established TBO garden and parks. NBM funds establishment of bambuseta, for *ex situ* conservation.

India is a mega biodiversity country, and there are many species which require conservation outside the original habitat. Availability of land outside the original habitat having similar growing conditions is a major constraint for conservation of many species. The other constraints to sustain *ex situ* collections are lack of funding and limited number of trained staff to cover all activities related with management of FGR. Lack of adequate facilities or infrastructure development is also a constraint in SFDs and in some organizations. Efforts for establishment and management of *ex-situ* areas need to be coordinated by a single nodal agency. There is a need for prioritization of the species for *ex situ* conservation based on demand for the species or economic value. *Ex-situ* conservation being a long term effort requires constant institutionalized support.

Defence Institute of High Altitude Research (DIHAR) has created a National Perma Frost Based Germplasm Storage Faciltiy at an altitude of 5360 m above mean sea level which will serve as a germplasm storage facility for current and future food security in the era of global warming and climate change, and the same can also be used for *ex situ* conservation of FGR.

The state of use and sustainable management of FGR

There are a large number of species that are presently under various stages of domestication in India. The importance of production forestry has been realized and strategic activities for tree improvement are in progress in the ICFRE institutes, State Forest departments and agricultural universities. ICFRE has developed comprehensive strategies for tree improvement of species like teak, neem, acacias, pines, eucalypts, bamboos, poplars, *Dalbergia* spp., *Casuarina* spp., *Cedrus deodara*, *Jatropha* spp., *Albizia* spp. and *Gmelina* spp. The ICFRE institutes have assembled germplasm of various species. Provenance trials at a national level for various species like *Dalbergia sissoo*, pines and acacias have also been conducted. Improved seeds from clonal seed orchards and seedling seed orchards of some species are made available for planting to user agencies. For the process of tree improvement of many of the exotic species, seeds have been transferred internationally under various programmes like FORTIP.

The tree improvement programmes undertaken in India have largely concentrated on increase in volume of timber, as that is the prime requirement, in a state of timber deficit. The primary breeding objective still remains volume increase in most of the breeding programmes. Wherever, the breeding programme has advanced beyond the first generation, other breeding objectives to improve the pulping or wood quality, pest tolerance, disease resistance, etc., are also being attended to. As a result of the ongoing tree improvement programmes, seed orchards have been established for many economically useful species. The seeds from these orchards are being supplied to the planting agencies, including farmers. The genetically improved seeds from these orchards are quite inadequate to meet the complete requirement of seeds, in respect of all the species that are planted.

Information on the ongoing tree improvement programmes is available in the form of Research reports, technical reports, annual reports and publications, which lie scattered. There is no system of collection, collation, analysis and transmission of data related to tree improvement to the user agencies.

The reproductive materials available from the seed orchards and vegetative multiplication gardens are now available for use by the farmers, forest departments and other research organizations. New varieties are being evolved and released for use. These are available only within the country, and so far no supply has been made internationally. Policy on this matter is yet to be taken. The improved reproductive material available in forestry were first classified in the country under the Scheme for certification of Forest Reproductive Material in 1972 later revised and issued in 1979 by the Government of India as 'Certification of Forest Reproductive Material in India (Revised Scheme, 1979)'. The scheme classified the forest reproductive material as, (1) Source identified reproductive material, (2) Selected reproductive material, (3) Reproductive material from untested seed orchards, and (4) Tested reproductive material. The scheme was meant for implementation by the States, but in the absence of a legal backing, this could not be enforced. For implementation of the abovesaid scheme, seed zoning was also done. The first attempt in India to create seed zones specifically to facilitate seed collection was taken up in 1978 by the Indo-Danish Project on Seed Procurement and Tree Improvement (IDPSPTI). The country was divided into 147 seed zones for the purpose of seed collection, movement and tree improvement activities. However, in the absence of legal enforcement of the scheme, the seed zones were also not given due importance. Now a Bill for enforcing this legally is pending before the Indian Parliament in the form of Forest Reproductive Material Certification Bill, 2008. Once this is passed and enacted, tree improvement would be invigorated in the country.

The state of national programmes, research, education, training and legislations

The management of forests is by the State governments, under the broad guidelines of the National Forest Policy, 1988. On a large number of issues of national importance, national programmes exist. In 1999 with the assistance from FAO, a National Forestry Action Programme (NFAP) was prepared which made Action Proposals for Forestry Research and Technology, which included *in-situ* and *ex-situ* conservation of forest genetic resources. It also made specific recommendations on use of forest genetic resources to augment the supply of industrial wood. Forestry research is attended to by the ICFRE and also by the research wings of the SFDs, and is largely in terms of the National Forestry Research Plan (NFRP) which has a national character and helps avoid duplication of research. National Wildlife Action Plan (NWAP) deals with the protection of flora and fauna in the Protected Area Network, and that indirectly deals with the FGR. National Biodiversity Action Plan (NBAP), 2008 and National Action Plan on Climate Change (NAPCC), 2008, Mangroves for the Future- National Strategy and Action Plan (MFF-NSAP), 2011 also deal with the conservation and use of biological resources, at national level.

The main institutions actively engaged in forest genetic resource conservation are the SFDs, directly concerned with *in-situ* conservation of forest genetic resources. There are 28 States and 7 Union territories that have their own forest departments as custodians of the forests and their genetic resources. The management of forests is in the mandate of these departments. Around 25 per cent of forest area extending over 22 m ha is under Joint forest management (JFM) with the people of villages adjoining forests. All the PAs where the biodiversity is conserved, whose sub-set is the Forest Genetic Resource (FGR) are under the control of forest departments.

The forestry research organizations, NGOs and wood based industries are mainly concerned with the *ex situ* conservation of forestry species of their interest. The ICFRE with its institutes maintains a large number of seed production areas, seedling seed production areas, seedling seed

orchards, clonal seed orchards, clone banks and vegetative multiplication gardens, as a part of FGR conservation and use. The Indian Council of Agriculture Research (ICAR) and its institutes concerned with agroforestry, the National Bureau of Plant Genetic Resources (NBPGR), New Delhi and the agricultural universities which conduct courses on forestry also maintain collections of forestry species in their *ex situ* conservation and tree improvement programmes. The Botanical gardens under the Indian Botanical Garden Network (IBGN) maintain forestry species in their collections all over India. There are also Non-governmental organizations, private research organizations and nurseries and wood-based industries that maintain collections of germplasm of forestry species.

At national level the first network programme for FGRs, was the IDPSTI. Subsequently ICFRE has managed programmes on collection, documentation, evaluation and use of tree genetic resources. Under the FORTIP (UNDP/FAO Regional Forest Tree Improvement Project) it procured germplasm of plantation species, such as Eucalyptus, Casuarina, Acacias, etc., which serve as the basis of the ongoing tree improvement programmes. Under the Planting Stock Improvement Programme (PSIP) of the Forestry Research, Education and Extension Project (FREEP) funded by the World Bank, ICFRE has established a large number of genetic resource stands.

The country is a part of the regional network, APFORGEN, established in 2003 for the purpose of FGR conservation and use. Research organizations within the country were also partners in certain species specific networks, such as, International Neem Network, TEAKNET, the International Network on *Leucaena* Research and Development (LEUCANET), the International Network on Bamboo and Rattan (INBAR), etc.

At present there is no exclusive legal framework governing the forest genetic resources. However, the legislations related to biodiversity conservation, sustainable use and access and benefit sharing (Biological Diversity Act, 2002) and the protection of farmers' rights and plant varieties (Protection of Plant Varieties and Farmers' Rights Act, 2001) have implications on forest genetic resources. The collection of forest genetic resources from wild and their transport are regulated by the Indian Forest Act, 1927, Wildlife (Protection) Act, 1972 and various State Forest Acts. The trade and export of the resources is governed by Convention on International Trade in Endangered species of fauna and flora (CITES), in respect of the endangered resources.

The national programme for forest genetic resources commenced only recently in 2011, and funding for the same shall start only in 2012. The needs and priorities are consolidation of the information and resources already available, and exploration of genetic variation in the forestry species already domesticated or in the process of domestication, throughout the natural range of the species, exchange of germplasm with countries having the same species in order to widen the germplasm base, testing and characterization of the germplasm and its use in breeding programmes to evolve new varieties suited to various requirements of the user agencies. The first step should be establishment of wide germplasm assemblages, which would primarily be field gene banks, followed by seed banks.

The main challenge to maintain the national programme for genetic resources would be the availability of trained manpower. The ICFRE has a strength of 362 scientists and 665 supporting staff, and is just equivalent in strength to a large institute in any other part of the world. This council maintains 8 institutes, all understaffed and overworked. With multiple mandates to undertake, the focus on forest genetic resources would be lost, if these institutes are not strengthened in terms of manpower. The next major challenge would be the availability of land for establishment of field gene banks. This problem can be solved, if this is done collaboratively with forest departments and

universities which own large extents of land. The collection of genetic resources across forests of the country would require assured mobility. This would be the next major challenge for the programme.

Financial allocation to forestry sector has always been less than 1% of the total budget of the government. Approximately 0.03% of the annual budget goes for conservation. Of this it is difficult to estimate how much goes towards forest genetic resources. It is miniscule compared to the amounts spent on other development sectors, or even other activities within the forestry sector. However, forestry research draws funds from various other organizations also like the Department of Biotechnology or Department of Science and Technology under the Ministry of Science and Technology for projects related to biotechnology or climate change, NMPB for projects related to medicinal plants, the NBM for projects on bamboo and the ICAR for projects on agroforestry. In the XII Five year Plan, under the Green India Mission, which is is one of the eight missions under NAPCC, funding is made available for afforestation and reforestation activities including research which would look into the FGR aspects also.

Forest genetic resource is not explicitly covered in any educational course in the country. It is part of the Forestry courses conducted in various agricultural universities. Some universities have specialization in Forest genetics and breeding at Masters level. Doctorate is awarded in subjects related to forest genetic resources and their conservation or use, in all the agricultural universities and the Forest Research Institute University.

The country is signatory to many conventions and treaties that are related to various aspects of biodiversity conservation, sustainable use and access and benefit sharing, besides protection of intellectual property rights. The provisions cover the forest genetic resources also. The main treaties, agreements and conventions are the Convention on Biological Diversity (CBD), CITES, FAO International Undertaking on Plant Genomic Resources, International Treaty on Plant Genetic Resources for Food and Agriculture, WTO Agreement on the Application of Sanitary and Phytosanitary Measures, Agreement on trade-related aspects of Intellectual Property Rights Systems (TRIPS), International Plant Protection Convention and the IUCN Global strategy for Plant conservation.

India has enacted over the past 10 years many legislations relevant to the conservation and sustainable use of forest genetic resources, besides equitable sharing of benefits, the notable being the Biological Diversity Act, 2002 and Biological Diversity Rules, 2004, regulating access to biological resources and associated traditional knowledge so as to ensure equitable sharing of benefits arising out of their use, in accordance with the provision of Article 15 of the CBD. The PPVFRA, 2001 and Protection of Plant varieties and Farmers' Rights Rules, 2003 deal with the protection of plant breeder's rights over the new varieties developed by them and the entitlement of farmers to register new varieties and also to save, breed, use, exchange, share or sell the plant varieties, which the latter have developed, improved and maintained over many generations. The Plant Quarantine (Regulation of import into India) Order, 2003 regulates the entry of germplasm into the country. The Patent Second Amendment Act 2002 and Patent Third Amendment Act 2005, provide for exclusion of plants and animals from the purview of patentability; exclusion of an invention which in effect is traditional knowledge from patentability; mandatory disclosure of the source and geographical origin of the biological material in the specification when used in an invention; and provision for opposition to grant of patent or revocation of patent in case of non-disclosure or wrongful disclosure of the source of biological material and any associated knowledge. The Scheduled Tribes and Other

Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, recognizes and vests the traditional rights to forest dwelling communities over access to forest goods and occupation in forest lands.

There is no legal framework for FGR strategies, plans and programmes. However, the National Biodiversity Action Plan (NBAP), 2008 serves as the framework for biodiversity related matters, including FGR, at present. In the absence of an exclusive legislation governing the forest genetic resources, the legislations related to biodiversity and the plant genetic resources, are applied to the FGR, as well. In view of the special nature of the FGR, such as, their location in forest areas that are remote and inaccessible, ownership with the State, traditional knowledge available with the forest dwelling tribals and the problems associated with biopiracy, a special legislation is needed.

The state of regional and international agreements and collaboration

The MoEF is the nodal agency for the agreements with United Nations Development Programme (UNDP), World Bank, United Nations Industrial Development Organization (UNIDO), United Nations Conference on Sustainable Development (UNCSD), United Nations Environment Programme (UNEP), Global Environment Facility (GEF) and regional bodies like Economic and Social Commission for the Asia and the Pacific (ESCAP), South Asian Association for Regional Cooperation (SAARC), South Asian Cooperative Environmental Programme (SACEP), Asian Development Bank (ADB), International Treaty on Plant Genetic Resources (ITPGR) and European Union (EU) in all matters related to Environment and Forests. India has participated actively in all the major international events related to Biodiversity Conservation over the past decades and has ratified all the major Biodiversity and Environment related global conventions.

India is among the 193 Contracting Parties to CBD and has developed legislation on accessing of Forest Genetic Resources. India is one amongst the seven Asian countries to have signed an agreement with Food and Agricultural Organization (FAO) to participate in the regional cooperative project "Establishment of the National Information Sharing Mechanism on the Implementation of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (PGRFA) in Asia and the Pacific Region".

India is part of the APFORGEN Network. India hosted the APFORGEN country coordinators meeting in 2006. It conducted a national consultative workshop on FGRs in 2007 at IFGTB, Coimbatore. A training workshop on Conservation and Management of FGR was also conducted at IFGTB, for the member countries of APFORGEN, in 2010. India also proposes to host the 5th International Conference on Casuarinas, in 2013, which will of interest to the members of APFORGEN network.

In a country like India with vast natural resources and diversity, the extent of effort required for FGR conservation is enormous. Thus, for effective conservation and management establishment of National FGR conservation, network is essential. There is also a need to strengthen capacities pertaining to research and development activities related to FGR in the country. Infrastructural facilities throughout the country should be improved for conducting advanced research. Human resource development of scientific/ technical personnel through national and international trainings will also lead towards efficient forest genetic resource conservation and management.

Access to forest genetic resources and sharing of benefits arising out of their use

The CBD recognizes bioresources as territorial asset and determining terms of accessing to them, subject to their national legislation. India has enacted the Biological Diversity Act, 2002 for accessing

biodiversity and associated traditional knowledge (TK), and also for sustainable use of its components and fair and equitable sharing of benefits arising out of their utilization. For a national legislation on access and benefit sharing (ABS) to be effective, its recognition at the international level is essential. India is a party to the Nagoya protocol and the national legislation is likely to be brought in on the Nagoya model. To bring the biological resources from other countries, India as a signatory to IPPC 1952 (modified 1997) has framed sufficient quarantine and phytosanitary measures which are also of regulatory nature and put no artificial barrier to trade. There is no difficulty right now in either accessing of our bioresources or sharing the resources from other nations. However, for collaborative research programmes bilateral/multilateral agreement and Material Transfer Agreement (MTAs) with inbuilt benefit sharing mechanism have to be worked out case by case. National Biodiversity Authority (NBA) and State Biodiversity Boards (SBB) are required to consult the Biodiversity Management Committees (BMC) on any decision regarding access and use of biodiversity within the jurisdiction of BMC. Ultimately BMC is the owner and custodian of bioresources within its jurisdiction.

Recently, the Government of India has enacted the The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 for empowering the tribal communities and other forest dwellers to have unhindered enjoyment of their traditional rights over the forest products at the same time imposing a duty on them in the conservation of forest and in the protection of FGR. However, the impact of this legislation is yet to be assessed.

Contribution of forest genetic resources to food security and poverty reduction

Forest Genetic Resources have the potential to emancipate people out of hunger and mitigate poverty by supplying the most basic needs for sustainable development of the forest dependent communities. Forests can provide a crucial contribution to Millennium Development Goals especially in achieving the environmental sustainability, poverty eradication and women empowerment. The trends indicate that planted forests and trees outside forests will also provide an increasing share of forest products. Edible wild fruits, bamboo seeds and wild legumes have played a very vital role in supplementing the diet of the rural communities. Tribal communities and ethnic tribes use wild edible plant species, including roots and tubers, leafy green vegetables, bulbs and flowers, fruits, seeds and nuts.

NTFPs are obtained from about 3,000 species in the country and form an important source of livelihood for communities, particularly tribals and rural poor living adjacent to forests. In India, NTFPs contribute an income equivalent of US$ 2.7 billion per year and absorb 55% of the total employment in the forestry sector. NTFP sector with annual growth rate between 5-15% contributes to 75% of forest sector export income. They provide 50% of the household income for approximately one-third of India's rural population. The undisclosed indigenous knowledge on medicinal trees held by the tribal communities is one of the valuable resources integrated with biodiversity. Protecting indigenous knowledge would benefit in treatment of ailments, reduction in child mortality rate and improvement of maternal health, when the modern healthcare systems are inaccessible and uneconomical for the forest dependents. Tribal households depend heavily on livestock husbandry in several states of the country because livestock keeping generates a continuous stream of income and employment. Tree genetic resources supplement the cattle feed and are also used in animal healthcare.

Forest dependent communities are involved through cooperative societies, in cultivation, collection and marketing of forest produce. Many forest departments in the country support such activities through special initiatives, as production, processing and marketing are complex issues to be handled. The Tribal Cooperatives Marketing Development Federation of India (TRIFED) under the Ministry of Tribal Affairs, GOI serves the interest of the tribal community and works for their socio-economic development by undertaking retail marketing of tribal products. TRIFED also conducts skill up-gradation training and capacity building programmes for the NTFP gatherers. Further, India being the sixth largest producer of honey in the world TRIFED has taken the initiative to create a "Wild Honey Network" for coordination and linkage among stake holders in wild honey and to develop the market of wild honey in an organized manner.

India's needs and priorities for forest genetic resource conservation and use

The forest departments, research institutes and other stakeholders handling the forest genetic resources in association with other government departments have to contribute to management and conservation of FGRs through an integrated approach. The areas that need urgent attention in the matter of biodiversity conservation including FGR conservation and management are: i) integrated database development at all organizational and management levels, to effectively utilize the data for decision making and establishment of a national information system, ii) skill development at all levels, especially related to new biotechnologies, benefit sharing mechanisms, tools in monitoring biodiversity including FGR diversity, iii) encouraging taxonomy related research, iv) monitoring and assessing biodiversity for representative landscapes on long term continous basis, v) climate change and FGR related research, vi) elimination of invasive alien species, that threaten the diversity, vii) incentives for sustainable utilization of resources, viii) sustained research on genetic diversity (MOEF, 2009).

A National seed procurement and distribution system, as envisaged earlier in the Certification of Forest Reproductive Material in India, (Revised scheme, 1979) has to be in place to coordinate, regulate and support tree planting activities in India, using improved planting stock. The passing of the Forest Reproductive Material Certification Bill, 2008 and its early enactment would pave way for use of improved planting stock in the plantation programmes of the country, and thus for improved productivity.

Along with the development of a national seed procurement and distribution system, the availability of the genetically improved seeds should also be augmented. A National Tree Seed Centre (NTSC) has to be established under ICFRE along with State Seed Centres (SSC) in research wings of SFDs. To increase the availability of quality seeds, besides the seed sources available with ICFRE and the forest departments, seed orchards are also to be established with the farmers and industries, in the form of Community Seed Orchards and Industrial Seed Orchards.

The plantation forests in India are dominated by monocultures of a few species like, *Eucalyptus*, *Tectona grandis,* Acacias*, Casuarina, Shorea robusta, Cedrus deodara, Pinus roxburghii, Pinus wallichiana, Gmelina arborea, Grevillea robusta*, etc., meeting the requirements of various industries. However, the average productivity of the plantations stands just at about 10 m^3/ha/yr., and this is not able to meet fully the raw material demand of the industries, which is steadily on the rise. The gap in the raw material supply to industries can be met to some extent by technology based plantations managed through industry- farmer linkage. Industrial agroforestry through a tripartite partnership among the research organizations supplying quality planting stock, farmers providing

their land and the industries providing assured buy-back arrangements, would give a boost to the plantation forestry sector.

Plantation forestry has to tap the potential of hybrid forestry. At present the hybrids in use are those of *Populus* and Acacias, and those developed and under testing are those of *Eucalyptus* and Casuarinas. More emphasis should be given on production of hybrids and their use as clones, to utilize the hybrid vigour and increase the productivity.

There are a large number of actions related to research and capacity building required to augment the *in situ* conservation efforts. Along with the conservation of ecosystem and biodiversity, the FGR also get conserved *in situ*, and this is preferred over *ex situ* conservation as the species is conserved in its original habitat, the diversity is maintained and the opportunities for the evolutionary processes to continue are there. The high cost and technology involved in *ex situ* conservation is also a factor not in favour of that, when options for *in situ* conservation are available. The priorities required for *in situ* conservation are i) species prioritization at country and regional level, ii) species recovery research, iii) documentation and assessment of status of globally threatened taxa in different parts of the country, iv) study on genetic, ecological and population dynamics of different species, v) relook into the earlier established PPP and establishment of new ones and monitoring, and vi) creation of certain endemic species protected areas.

For ex-situ conservation, strategies need to be developed with expert vision to cater to the future needs. As there are many priority species, the efforts need to be taken up by many agencies are to be coordinated by a nodal agency. The efforts must be proportional to the present knowledge on the utility of the species. The germplasm must be collected scientifically considering the variability present in different populations covering the core population and other populations in a proportion. For better management practices to reduce genetic changes or loss of genetic integrity, attention must be paid to select suitable regeneration environment, adequate population size and proper handling of regenerated material. In future collection for *ex situ* conservation stands should aim at capturing maximum genetic diversity through prior knowledge on the extent and pattern of genetic variation within the species. Genetic diversity studies at DNA level and gene-ecological studies are needed for planning the *ex situ* germplasm collection. Capacity building is needed in these areas. For future conservation strategies, a national strategy for conservation and management of FGR similar to national strategies on wildlife, biodiversity, etc., is to be formulated. Information on the ongoing tree improvement programmes needs to be collected, collated, analysed and transmitted to the user agencies. For this purpose, the Ministry of Environment and Forests has recently sanctioned an Information system, called the ENVIS (Environmental Information System), an intergrated database on FGR to be managed by the IFGTB.

Documentation of the FGR is the prime necessity. Publications highlighting the role of FGR in the socio-economic well being of the people have to be made. More research is required on exploration of FGR. The genetic diversity of many species is yet to be unraveled. Provenance delimitation, assessment of the genetic diversity, assemblage of germplasm, characterization and use in breeding programmes has to be carried out for many of the economically important species. While awareness on biodiversity is increasing, many fail to understand the subtle difference between biodiversity and FGR. More education and training programmes on FGR are required even for the forestry professionals who are managers of the FGR. The forestry scientists and the

extension personnel also need a sound understanding of the importance of FGR conservation and use, and accordingly training and orientation programmes are required to be organized.

There is a need for targeted FGR information, to be disseminated to the forest managers, forest dwelling people, forest dependent industries and the general public, in order to promote conservation and sustainable use of FGR and equitable sharing of benefits arising out of its use. Training programmes on identification, non-destructive harvest, processing and storage of harvested material and marketing, have to be imparted to all the stakeholders.

There is also a need to strengthen capacities pertaining to research and development activities related to FGR in the country. Infrastructural facilities throughout the country should be improved by enhanced and continual allocation of monetary resources for conducting advanced research. Human resource development of scientific/ technical personnel through national and international trainings will also lead toward efficient forest genetic resource conservation and management.

While lots of efforts have gone in the assemblage of germplasm, limited efforts are being taken for phenotypic, biochemical and molecular characterization of germplasm for different traits like pest, drought and salt tolerance, better wood traits and medicinal properties especially in indigenous species. Thus understanding the state of diversity with respect to these traits would therefore require coordinated efforts of domain experts from various international laboratories for incorporating the modern phenomic, genomic, proteomic and metabolomic technologies. Infrastructure facilities and human resource development in these areas in forestry research institutes through collaborative ventures is therefore important.

High priority need to be given for raising awareness on the needs for international collaboration and networking for enhancing *ex situ* management and conservation, research, education and training and information management and early warning systems for forest genetic resources. For efficient coordination and management of FGR at national and regional levels, there should be mechanisms to strengthen and support networking, information sharing, capacity-building and research endeavours, may be with international collaboration in future.

National level database on precise baseline genetic information and demand and supply of various FGRs for the forest based industries should be targeted. Processing units for various minor forest products and state regulated trade has to be strengthened. Promotion of cultivation and up gradation of skills on processing has to be intensified. An umbrella organization, the NBFGR, exclusively for FGR management with appropriate linkage with SFDs, research institutions, universities and forest based industries has to be created for systematic updation of data. Encouragement of regional co-operations and networking of FGR improvement would lead to economic and social advancements. Hence, development of shared activities on common priority species, establishment of regional repositories of FGRs, exchange of germplasm and scientific knowledge on the status of important FGRs would support conservation. Globally scientific advances in frontier technologies (genomics, bioprospecting, DNA barcodes, and cryotechnology) need to be shared for meeting the regional demands. Mutually acceptable legal commitments are required to be developed for ensuring equitable utilization of forest genetic resources of the participating countries.

SECTION II

INTRODUCTION TO THE COUNTRY AND FOREST SECTOR

India is a distinct geographical unit in South Asia, located between 8°4' to 37°6' N latitude and 68°7' to 97°25'E longitudes. It is the 7th largest country in the world with a land area of 3 287 263 sq.km. India is the second most populated country in the world with a population of 1 210 193 422 and an average population density of 382 / sq.km (GOI, 2011).

The recorded forests in the country include the areas under forestry as the land use and also some areas recorded as forests while not under tree cover, such as rocks, deserts, mountain ranges, etc. The recorded forests inclusive of these categories extend over 76.962 m ha forming 23.41% of the geographical area of the country (MoEF, 2009). The total forest cover of the country is 69.20 m ha which is 21.05% of the geographical area while the tree cover is 9.08 m ha which accounts for 2.76% of the geographical area. In total the forest and tree cover is 78.29m ha accounting for 23.81% of the geographical area (FSI, 2011).

India ranks 10th among the ten most forested countries of the world. The details of main forest characteristics and ownership as reported in the Global Forest Resources Assessment 2010 are furnished in Tables 1 and 2 (FAO, 2010a). The area under agroforestry systems in the country, not mentioned in the FRA is 7.45 m ha.

Table 1.

Forest characterisitics and area (FRA)

Main forest characterisitics	Area (ha)
Primary forests	15 701 000
Naturally regenerated forests	42 522 000
Planted forests	10 258 000
Reforestation	
Afforestation	
TOTAL	**68 481 000**

Table 2.

Forest ownership and area (FRA)

Forest ownership	Area (ha)
Public ownership	58 007 000
Private ownership	9 702 000
Others	-

The forests of the country fall into five major categories and 16 groups, based on biophysical criteria (Champion and Seth, 1968). The distribution of the major groups indicates 41.87 % Tropical dry deciduous, 19.73 % Tropical moist deciduous, 2.25 % Tropical thorn and 2.92 % Tropical wet evergreen forests, other minor types forming the rest of the forests (FSI,2011). The forests are concentrated mainly in the North-eastern States, the Himalayas and Shiwalik ranges, the Central highlands, Andaman and Nicobar Islands, strips along the Western Ghats, the Eastern Ghats and other hilly areas and in Coastal Mangroves.

In contrast to the global trend of decreasing forest cover, India has been successful in arresting the decline and stabilizing the area under forest cover showing a decadal increase of 3.04 m ha between 2000 and 2010 registering an annual increase of 0.46 %. India ranks 4th in terms of the annual increase in planted forests, in the last 20 years registering an average increase of 251 000 ha/year. The planted forests occupy 5 % of the forest cover. Out of this 13 % is of the introduced species and 87 % native. In terms of function the production functions are served by 25 % of forests and protection of soil and water by 16 %, conservation of bio-diversity by 29 % and multiple uses by 30 % (FAO, 2010b).

India is one of the 17 mega-diversity countries of the World and stands 8th in the world ranking of mega-biodiversity countries, according to species richness of mammals, birds and flowering plants (Paine, 1997). It houses parts of four global biodiversity hotspots out of 34, which include the Eastern Himalayas, Indo-Burma, Western Ghats /Sri Lanka and a part of Sundaland in the Nicobar Islands. Much of this biodiversity is conserved in the forests.

The management of the forests rests with the State governments and the Central government provides the necessary policy guidelines and funding support. The present management of the forestry sector is guided by the National Forest Policy of 1988, which made a paradigm shift from a focus on sustained timber yield to sustainable forest management encompassing in it environmental, economic and social dimensions. In the past decade, conservation and management of forests has been strengthened through various policy and legal frameworks, such as, the Biological Diversity Act, 2002, National Wildlife Action Plan (2002-2016), National Environment Policy (NEP), 2006, National Biodiversity Action Plan, (NBAP), 2008 and National Action Plan on Climate change (NAPCC), 2008. The management of the natural forests is oriented towards the ecosystem services and addressing the livelihood of forest dwellers and forest fringe villages.

The domestic and industrial requirements of timber and other forest produce are met largely from the planted forests. The plantation area in India is 32.57 m ha which accounts for 17% of the global plantations and is the 2nd largest in the world after China. It also has the largest share in teak plantations of the world (44%). India is the largest planter of *Eucalyptus* in the world with more than 4 m ha under cultivation. 1.5 million m^3 of rubber wood is available and is expected to reach 14 million m^3 by 2020 (MoEF, 2009). 9% of global wood removal is from India which stands 2nd in terms of volume removed (FAO, 2010b).

The growing stock of Indian forests is estimated at 4 498.73 m m^3 and of the Trees outside forests (TOF) is 1 548.42 m m^3. The estimated removal of wood from forests annually is 3.157 m m^3 and from TOF is 42.77 m m^3. The TOF provides almost 80% wood requirement (FSI, 2011). The Mean Annual Increment (MAI) of the planted forests range from 10 to 60 m^3 /ha/yr, especially those of poplar and eucalypts; however the MAI of natural forests is just 0.5 m^3/ha/yr as against the world average of about 2 m^3/ha/yr. This low productivity is mainly due to fire, grazing, over-exploitation

and non-recycling of biomass in forest soil. It is estimated that 1.6 m ha are affected by fire annually and 25.5 m ha are affected by grazing. In total nearly 44% of Indian forests are affected by biotic and abiotic stresses, adversely affecting the productivity (MoEF, 2009; FAO, 2010b).

In spite of the low productivity and the continuously increasing demand, the forests continue to serve as source of timber, fodder, fuel wood, food, medicine and source of livelihood to a large number of forest dwellers and rural population. It is estimated that nearly 27% of the Indian population depends on forests for their livelihood. The annual consumption of wood in household construction and furniture, industries and agriculture is around 48 m m^3. 23% of the population are dependent on fuel wood collected from forests (58.75 m tonnes), and the total annual consumption of fuel wood is estimated at 216.42 m tonnes. Though major part of the fuel wood demand is absorbed by the TOF, much of fuel wood is collected from the forests in an unorganized way and is an important factor impacting the growing stock and ecological balance. The non-timber forest-produce (NTFP) also contributes significantly to the economy. The NTFPs account for 70% of India's exports of forest produce. More than 100 million people depend on the sale of NTFP for livelihood. Nearly 39% of cattle depend on forests for their fodder either partially or fully.

The requirement of wood and wood products is bound to increase in future, due to various economic and policy initiatives. The increased emphasis on education and hike in budgetary allocation is going to increase the demand for paper and pulp. The development of infrastructure and housing will also require substantial wood and wood products. Assuming a requirement of 2 m^3 per household for construction and furniture an additional requirement of 50 m^3/yr is projected (MoEF, 2009). Wood requirement for meeting domestic energy requirement is expected to be stable, in view of switch-over to non-wood sources of fuel. However, demand for biomass for production of electrical energy is likely to increase in view of the benefits under Clean Development Mechanism (CDM).

For wood utilization in India, there are about 23 000 sawmills, 950 units manufacturing wood based panels and veneer; 380 units producing pulp, paper and paper boards; 5 units of safety match and an unknown number of cottage match units. 90% of these units are in the small-scale. Most of these wood based industries are short of investment capital, hire unrecognized and legally unprotected labour, use outdated machinery and characterized by poor management and technical skills (MoEF, 2009).

In timber trade, India is a net importer of forest products; the largest share occupied by logs, followed by paper and paperboards and recovered paper. Supply of logs is mainly from Myanmar, Indonesia, Malaysia and several African and South American countries (MoEF, 2009).

The main drivers of changes in the forestry sector are the demographic change, agriculture, infrastructure and industrial growth, urbanization, economic changes, climate change and the political and institutional environment. India's population is projected to touch 1.33 billion by 2020, at a growth rate of 1.38% per annum. The dependency of the population on forest is showing a declining trend and from about 40% in 1990 it is expected to decrease to 34% by 2020. However, the absolute size of the population dependent on forests would increase due to increase in population, and the demand for forest products would keep increasing. Agriculture remains the primary occupation for a majority in rural India, and occupies 42% of the land area. With increasing focus on rainfed areas, diversification of agricultural practices and the new initiatives in agroforestry the TOF are likely to increase in future. The focus on small and medium enterprise sector in Industrial

development, which includes agro- and rural industry consuming a large proportion of forest products, is likely to boost the social forestry and farm forestry. The growing urbanization places demand for housing and consequently for wood based construction material, most of which is made from plantation grown-short rotation species, and this would give a boost to agroforestry. The Indian economy that is currently growing at the rate of 9% per annum puts pressure on environmental resources for physical infrastructure (MOEF, 2009). The role of forests in mitigation of climate change is now well recognized and it is estimated that the Indian forests hold a carbon stock of 6923 m tonnes (FAO, 2010b). Hence, in the National Mission for a Green India, which is a part of the NAPCC, the aim is to double India's afforested areas by 2020, adding an additional 10 million ha (MOEF, 2011).

The forestry sector in India needs to gear up to deal with emerging demands and challenges. Increasing inter-sectoral linkages have to be understood. The use of modern technologies and concepts in natural resource management and compatible changes in governance and documentation systems, with accountability and transparency is the need of the hour.

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SECTION III

CHAPTER 1

THE CURRENT STATE OF FOREST GENETIC RESOURCES

India is floristically rich with over 46 000 species of plants, representing 11% of world flora. In terms of plant diversity India ranks 10th in the world and 4th in Asia. India has about 17 527 species of flowering plants, and about 2 863 are trees which include some of the highly valued timbers of the world (MOEF, 2009). The vegetation is diverse ranging from xerophytes of the Thar Desert, evergreens of the Northeast and the Western Ghats, mangroves of coastal areas, conifers of the hills and the dry deciduous forests of central India to alpine pastures in the high reaches of the Himalayas. About 60 per cent forests in India are located in ecologically sensitive zones, such as, the Himalayas, Western Ghats and the Andaman and Nicobar Islands.

1.1 State of diversity within and between forest tree species

The forests of India are classified into 16 major forest types (Champion and Seth, 1968) and these forests house a wide array of species diversity. The major forest types and the main species in each type are presented in Table 3 (FSI, 1995; 2011).

Table 3.

Major forest type categories and main tree species.

Major Forest Types	Area (covered by forest type) (1000 ha)	Main species for each type	
		Trees	**Other species if applicable**
1. Tropical wet evergreen forest	5 414	*Dipterocarpus tuberculatus, Dipterocarpus macrocarpus, Diospyros angustifolia, Artocarpus heterophyllus, Hopea parviflora, Canarium strictum, Mesua ferrea, Vateria indica, Knema*	*Calophyllum soulattri, Artocarpus hirsutus, Palaquium ellipticum, Myristica dactyloides, Dendrocalamus hamiltonii, Bambusa tulda, Wendlandia wallichii*

			attenuata , Syzygium cumini	
2.	Tropical semi-evergreen forest	2 946	*Dipterocarpus indicus, Acrocarpus fraxinifolius, Xylia xylocarpa, Terminalia myriocarpa, Terminalia tomentosa, Calophyllum elatum, Diospyros ebenum, Vateria indica, Mangifera indica, Mimusops elengi, Vitex altissima, Tamarindus indica*	*Schleichera oleosa, Bambusa bambos, Dendrocalamus hamiltonii, Melocanna bambusoides, Artocarpus hirsuta, Neolamarckia cadamba, Caryota urens, Ceiba pentandra, Michelia champaca, Syzygium cumini*
3.	Tropical moist deciduous forest	24 284	*Tectona grandis, Shorea robusta, Albizia lebbek, Duabanga grandiflora, Gmelina arborea, Lagerstroemia lanceolata, Pterocarpus dalbergioides, Pterocarpus marsupium, Terminalia bialata, T. manii, T. procera, Chukrasia tabularis*	*Adina cordifolia, Syzygium cumini, Mallotus philippensis, Dedrocalamus strictus, Terminalia bellirica, Mitragyna parviflora, Anogeissus latifolia*
4.	Littoral and swamp forest	481	*Manilkara littoralis, Calophyllum inophyllum, Thespesia populnea, Rhizophora* spp.*, Ceriops tagal, Bruguiera gymnorhiza, Avicennia marina, Myristica dactyloides*	*Morinda citrifolia, Vitex negundo, Hibiscus tiliaceus, Sonneratia* spp.*, Excoecaria agallocha*
5.	Tropical dry deciduous forest	19 156	*Tectona grandis, Anogeissus latifolia, Terminalia paniculata, Chloroxylon swietenia, Buchanania lanzan, Dendrocalamus strictus, Santalum album*	*Sterculia urens, Hardwickia binata, Butea monosperma, Shorea robusta, Aegle marmelos, Acacia arabica, Pongamia pinnata, Tamarindus indica, Phyllanthus emblica, Adina cordifolia, Madhuca indica, Acacia catechu*

6.	Tropical thorn forest	1 827	*Acacia catechu, Anogeissus pendula, Acacia leucophloea, Ziziphus jujuba, Butea monosperma Albizia amara, Azadirachta indica, Prosopis spicigera, Capparis decidua*	*Acacia senegal, Cassia auriculata, Sida cordifolia, Tephrosia* spp.
7.	Tropical dry evergreen forest	165	*Atalantia monophylla, Bridelia retusa , Borassus flabellifer, Manilkara hexandra, Mimusops elengi, Diospyros ebenum, Memycylon edule, Strychnos nux-vomica, Calamus rotang, Calophyllum inophylllum, Semecarpus anacardium*	*Chloroxylon swietenia, Albizia amara, Sapindus emarginatus, Tamarindus indica, Gmelina arborea, Syzygium cumini, Strychnos potatorum, Annona squamosa, Phyllanthus emblica, Mitragyna parvifolia*
8.	Sub-tropical broad-leaved hill forest	303	*Castanopsis kurzii, Quercus dealbata Quercus griffithii, Schima khasiana, Myrica esculenta, Ficus nerifolia, Eurya japonica, Rhododendron arboretum, Pinus kesiya*	*Ochlandra travancorica, Dalbergia latifolia, Machilus macrantha, Terminalia chebula, Symplocos racemosa, Taxus baccata*
9.	Sub-tropical Pine forest	4 743	*Pinus roxburghii, Pinus khasya, Pinus insularis, Shorea robusta, Anogeissus latifolia, Cordia vestita*	*Salix tetrasperma, Terminalia chebula, Lannea coromandelica*
10.	Sub-tropical dry evergreen forest	1 248	*Acacia modesta, Albizia procera, Albizia amara, Azadirachta indica, Canthium dicoccum, Chloroxylon swietenia, Dalbergia paniculata, Garcinia spicata, Manilkara hexandra, Memycylon umbellatum, Pongamia pinnata, Syzygium cumini*	*Dodonea viscosa, Punica granatum , Garcinia gummi-gutta, Diospyros ebenum, Acacia chundra, Albizia odoratissima, Canarium strictum, Dillenia pentagyna, Pistacia chinensis*

11. Montane wet temperate forest	2 593	*Syzygium montana , Syzygium arnottianum, Syzygium calophyllifolium, Meliosma wightii, Symplocos cochinsinensis, Michelia nilagirica, Elaeocarpus oblongus, Acer campbellii, Rhododendron arboreum, Magnolia campbellii*	*Mahonia leschenaultii, Machilus macrantha, Litsea wightiana, Photinia notoniana, Viburnum erubescens, Cinnamomum sulphuratum, Ligustrum robustum*
12. Himalayan moist temperate forest	2 447	*Abies pindrow, Cedrus deodara, Picea smithiana, Pinus wallichiana, Taxus baccata, Tsuga dumosa*	*Aesculus indica, Populus ciliata, Prunus cornuta, Juglans regia, Quercus dialata*
13. Himalayan dry temperate forest	32	*Acer caesium, Fraxinus xanthoxyloides, Pinus gerardiana, Pyrus lantana, Quercus semecarpifolia, Quercus ilex, Taxus baccata*	*Acer acuminatum, Corylus jacquemontii, Juglans regia, Malus baccata, Hippophae solicifolia, Populus ciliata, Prunus mira*
14. Sub-alpine forest	2 067	*Abies spectabilis, Betula utilis, Juniperus polycarpus, Juniperus recurva, Elaeagnus angustifolia,Populus ciliata*	*Acer caesium, Hippophae rhamnoides, Juniperus wallichiana, Pinus wallichiana, Salix* spp.*,Taxus baccata*
15. Moist alpine scrub		*Betula utilis, Salix* spp.*, Rhododendron decipiens, Acer campbellii*	*Juniperus communis*
16. Dry alpine scrub		*Hippophae rhamnoides, Juniperus recurva, Rhododendron anthopogon, Salix* spp.	*Juniperus wallichiana*

The Indian sub-continent has also been divided into 10 biogeographic regions, namely, the Trans-Himalayan, Himalayan, Desert, Semi-arid, Western Ghats, Deccan Plateau, Gangetic Plain, Northeast, Islands and the Coastal zone (Rodgers and Panwar, 1988). The classification was done using various factors such as altitude, moisture, topography, rainfall, etc.

The forest cover in India has been classified based on canopy density by Forest Survey of India (FSI, 2011) and the Very dense forest (with canopy density > 70%) occupies 8.3 m ha (2.54% of land area); Moderately dense forest (canopy density of 40-70%) occupies 32.07 m ha (9.76% of land

area) and the Open forests (canopy density of 10-40%) occupy 28.78 m ha (8.75% of land area). Total land area under forest cover is 69.20 m ha forming 21.05% of land area.

The documentation of species variation within the forests is done by the BSI, established in 1890, with a mandate of survey, identification and recording status of the plant resources including forest genetic resources. The map (Fig. 1) shows the details of survey already conducted by BSI. It is reported that 46 042 species of plants occur in India, of which flowering plants account for 17 527 species. Till date, taxonomic account of more than 100 plant families (out of about 300 currently known to occur in India) has been completed. Details of 86 families have been published in Flora of India Vols. 1 – 5, 12 and 13, whereas about 3 families constituting Flora of India vols. 6 – 7 are under process of publication. Revisionary studies completed for 45 families (some partly) for Flora of India have been published in the form of Fascicles (1 – 24).The State Flora of Tamil Nadu, Karnataka, Himachal Pradesh, Arunachal Pradesh, Sikkim, Meghalaya, Tripura, Goa, Daman & Diu, Dadra & Nagar Haveli, Rajasthan, Saurashtra, Madhya Pradesh, Maharashtra, Punjab and Uttar Pradesh have been published whereas, those of Kerala, Manipur, Andaman & Nicobar Islands and West Bengal have been partly published and that of Mizoram and Jammu & Kashmir are currently under publication. The Survey has also published a large number of District Floras (BSI, 2012).

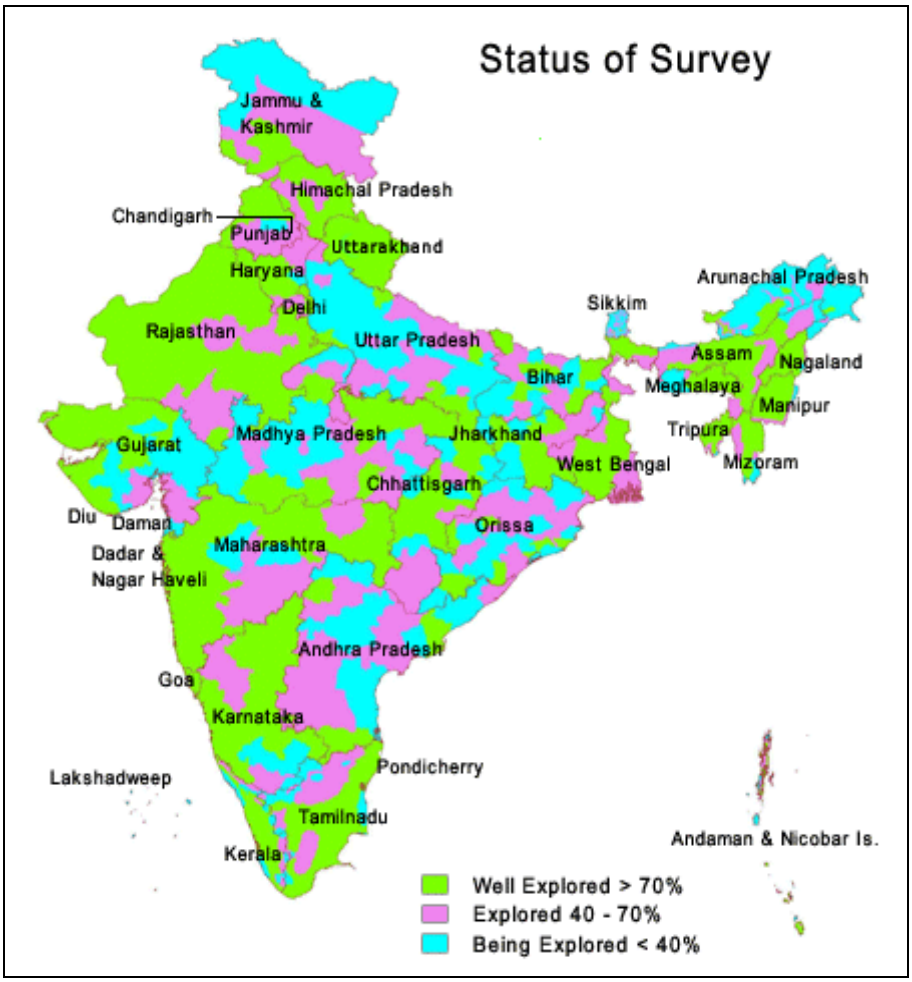

Fig 1. Details of survey conducted by BSI

On the basis of these surveys, 46 042 plant species have been recorded, including virus and bacteria (850), algae (7 175), Fungi (14 500), Lichens (2 223), Bryophytes (2 500), Pteridophytes (1 200), Gymnosperms (67) and Angiosperms (17 527). Five Biosphere Reserves (BR), namely, Great Nicobar, Nilgiri, Gulf of Mannar, Manas and Nanda Devi and 31 National Parks have been surveyed and taxonomic accounts of 4 Biosphere Reserves and 5 National Parks have been published. Besides, accounts of the floristic diversity in 23 Tiger Reserves and some selected Wildlife Sanctuaries have also been brought out. Under a recently sanctioned research project by MoEF, Government of India, entitled "Assessment of Floristic Diversity in Protected areas of India, Phase – I: - The Biosphere Reserves and National Parks", survey has been taken up for detailed study of the various aspects of the floristic diversity in the remaining Biosphere Reserves and National Parks of the country.

The survey of forest resources was initiated by the Government of India in 1965 with the project called the "Pre-Investment Survey of Forest Resources" (PISFR), with the sponsorship of FAO and UNDP. The main objective of PISFR was to ascertain the availability of raw material for establishment of wood based industries in selected areas of the country. In its report in 1976, the National Commission on Agriculture (NCA) recommended for the creation of a National Forest Survey Organization for a regular, periodic and comprehensive forest resources survey of the country leading to creation of FSI. As per the mandate redefined in 1986, the FSI prepares the State of Forest Report biennially, providing assessment of latest forest cover in the country and monitoring changes in these and also conducts inventory in forest and non-forest areas and develops database on forest tree resources.

Since the study of specific variation itself is far from adequate, the studies on intraspecific variation are limited. The studies on genetic diversity are confined to a few economically important species that are under the process of domestication. Such studies have been carried out based on morphological variations as well as molecular differentiation. These studies are important in the domestication of a species, to exploit the genetic variation for the purpose of breeding and genetic improvement, which can lead to increased productivity. The details of the intraspecific variation studies are discussed in Table 9 in this Chapter.

1.2. The main value of Forest Genetic Resources

Based on the economic utility and conservation value, a large number of forest tree species have been prioritized for conservation and use. APFORGEN and FAO had identified priority species for the country to concentrate on tree improvement and conservation efforts. The SFDshave also attended to improvement of species of significance in the respective States. Recently, in the 'Consultative Workshop on Strategies for Formulation of Forest Genetic Resources Management Network' held at the IFGTB, Coimbatore in March 2011, with the participation of stakeholders concerned with FGR, an exercise for prioritizing economically important tree species was carried out, and 30 tree species that need immediate attention under FGR research and conservation were identified (Krishnakumar *et al*., 2011). Apart from this ICFRE has identified important tree species for research under All India Co-ordinated Programme (AICP) under four major research thrust areas, namely, managing forests and forest products for livelihood support and economic growth, biodiversity conservation and ecological security, forests and climate change and forest genetic resource management and tree

Improvement. A complete list of all such species identified through priority setting exercises, is furnished in Table 4.

Table 4

Priority species for the country

S.No.	Priority species			Reason for priority
	Scientific names	Tree (T) or other (O)	Native (N) or exotic (E)	
1.	*Abies pindrow*	T	N	Economic
2.	*Abies spectabilis*	T	N	Economic
3.	*Acacia alata*	T	N	Economic
4.	*Acacia albida*	T	E	Economic
5.	*Acacia aulacocarpa*	T	E	Economic
6.	*Acacia auriculiformis*	T	E	Economic
7.	*Acacia catechu*	T	N	Economic; Threatened
8.	*Acacia chundra*	T	N	Economic
9.	*Acacia crassicarpa*	T	E	Economic
10.	*Acacia leucophloea*	T	N	Economic
11.	*Acacia mangium*	T	E	Economic
12.	*Acacia mearnsii*	T	E	Economic; Invasive
13.	*Acacia nilotica*	T	N	Economic
14.	*Acacia occidentalis*	T	N	Economic
15.	*Acacia senegal*	T	E	Economic
16.	*Acacia tortilis*	T	N	Economic
17.	*Acrocarpus fraxinifolius*	T	N	Economic
18.	*Adenanthera pavonina*	T	N	Economic
19.	*Aegle marmelos*	T	N	Economic;Social/cultural
20.	*Agalia andamanica*	T	N	Economic
21.	*Ailanthus excelsa*	T	N	Economic
22.	*Ailanthus kurzii*	T	N	Economic; Threatened
23.	*Ailanthus triphysa*	T	N	Economic
24.	*Albizia amara*	T	N	Economic
25.	*Albizia chinensis*	T	N	Economic
26.	*Albizia lebbeck*	T	N	Economic
27.	*Albizia odoratissima*	T	N	Economic
28.	*Albizia procera*	T	N	Economic
29.	*Albizia richardiana*	T	N	Economic
30.	*Alnus nepalensis*	T	N	Economic
31.	*Alnus nitida*	T	N	Threatened
32.	*Alstonia scholaris*	T	N	Economic
33.	*Amoora wallichii*	T	N	Economic
34.	*Anacardium occidentale*	T	N	Economic
35.	*Anogeissus latifolia*	T	N	Economic
36.	*Antiaris toxicaria*	T	N	Economic
37.	*Aphanamixis polystachya*	T	N	Economic
38.	*Aquilaria khasiana*	T	N	Economic; Threatened

39.	*Aquilaria malaccensis*	T	N	Economic; Threatened
40.	*Artocarpus chaplasha*	T	N	Economic
41.	*Artocarpus gomezianus* ssp. *zeylanicus*	T	N	Economic
42.	*Artocarpus heterophyllus*	T	N	Economic
43.	*Artocarpus hirsutus*	T	N	Economic; Threatened
44.	*Avicennia marina*	T	N	Economic
45.	*Azadirachta indica*	T	N	Economic
46.	*Baccaurea courtallensis*	T	N	Economic
47.	Bamboos	T	N	Economic
48.	*Barringtonia racemosa*	T	N	Economic
49.	*Bauhinia purpurea*	T	N	Economic
50.	*Bauhinia racemosa*	T	N	Economic
51.	*Bauhinia variegata*	T	N	Economic
52.	*Bentinckia condapanna*	T	N	Economic; Threatened
53.	*Bischofia javanica*	T	N	Economic
54.	*Bombax ceiba*	T	N	Economic
55.	*Bombax insigne*	T	N	Threatened
56.	*Borassus flabellifer*	T	N	Economic
57.	*Boswellia serrata*	T	N	Economic
58.	*Bracantomalum mangifera*	T	N	Economic
59.	*Bridelia retusa*	T	N	Economic
60.	*Bruguiera sexangula*	T	N	Threatened
61.	*Buchanania lanzan*	T	N	Economic
62.	*Butea monosperma*	T	N	Economic
63.	*Calophyllum calaba*	T	N	Economic
64.	*Calophyllum inophyllum*	T	N	Economic
65.	*Canarium euphyllum*	T	N	Economic
66.	*Canarium strictum*	T	N	Economic; Threatened
67.	*Canthium dicoccum*	T	N	Economic
68.	*Caryota urens*	T	N	Social
69.	*Cassia fistula*	T	N	Economic
70.	*Cassia siamea*	T	N	Economic
71.	*Casuarina cunninghamiana*	T	E	Economic; Threatened
72.	*Casuarina equisetifolia*	T	E	Economic
73.	*Casuarina junghuhniana*	T	E	Economic
74.	*Cedrus deodara*	T	N	Economic
75.	*Celtis australis*	T	N	Economic
76.	*Ceriops tagal*	T	N	Threatened
77.	*Chloroxylon swietenia*	T	N	Threatened
78.	*Chukrasia tabularis*	T	N	Economic
79.	*Cinnamomum cecidodaphnae*	T	N	Economic;Threatened
80.	*Cinnamomum tamala*	T	N	Economic
81.	*Cocos nucifera*	T	N	Economic
82.	*Commiphora wightii*	T	N	Economic; Threatened
83.	*Cordia myxa*	T	N	Economic
84.	*Corypha umbraculifera*	T	N	Economic

85.	*Cratoxylon formosum*	T	N	Economic
86.	*Cullenia exarillata*	T	N	Economic
87.	*Cupressus torulosa*	T	E	Economic
88.	*Dalbergia latifolia*	T	N	Economic
89.	*Dalbergia sissoides*	T	N	Economic
90.	*Dalbergia sissoo*	T	N	Economic
91.	*Dillenia indica*	T	N	Economic
92.	*Dillenia pentagyna*	T	N	Economic
93.	*Diospyros ebenum*	T	N	Economic; Threatened
94.	*Diospyros marmorata*	T	N	Economic
95.	*Diospyros melanoxylon*	T	N	Economic
96.	*Dipterocarpus* spp.	T	N	Economic
97.	*Duabanga sonneratioides*	T	N	Economic
98.	*Dysoxylum malabaricum*	T	N	Economic; Threatened
99.	*Elaeis guineensis*	T	E	Economic
100.	*Elaeocarpus tuberculatus*	T	N	Economic
101.	*Endospermum chinensis*	T	N	Economic
102.	*Eucalyptus* spp.	T	E	Economic
103.	*Evodia glabra*	T	N	Economic
104.	*Ficus* spp.	T	N	Economic;Social/cultural
105.	*Fraxinus xanthoxyloides*	T	N	Economic
106.	*Ganophyllum falcatum*	T	N	Economic
107.	*Garcinia gummi-gutta*	T	N	Economic
108.	*Garcinia indica*	T	N	Economic
109.	*Garcinia spicata*	T	N	Threatened; Social/cultural
110.	*Garuga pinnata*	T	N	Economic
111.	*Givotia moluccana*	T	N	Economic
112.	*Gluta travancorica*	T	N	Economic; Threatened
113.	*Gmelina arborea*	T	N	Economic
114.	*Grevillea robusta*	T	N	Economic
115.	*Grewia optiva*	T	N	Economic
116.	*Grewia tiliifolia*	T	N	Economic
117.	*Gyrocarpus asiaticus*	T	N	Economic
118.	*Haldina cordifolia*	T	N	Economic
119.	*Hardwickia binata*	T	N	Economic
120.	*Hevea brasiliensis*	T	E	Economic
121.	*Hildegardia populifolia*	T	N	Economic; Threatened
122.	*Holoptelea integrifolia*	T	N	Economic
123.	*Hopea odorata*	T	N	Economic
124.	*Hopea parviflora*	T	N	Economic
125.	*Hopea utilis*	T	N	Economic
126.	*Jatropha curcas*	T	E	Economic
127.	*Juglans regia*	T	N	Economic
128.	*Khaya anthotheca*	T	E	Economic
129.	*Khaya senegalensis*	T	E	Economic
130.	*Kingiodendron pinnatum*	T	N	Economic; Threatened
131.	*Knema attenuata*	T	N	Economic

132.	*Kydia calycina*	T	N	Economic
133.	*Lagerstroemia hypoleuca*	T	N	Economic; Threatened
134.	*Lagerstroemia microcarpa*	T	N	Economic
135.	*Lagerstroemia parviflora*	T	N	Economic
136.	*Lagerstroemia speciosa*	T	N	Economic
137.	*Lannea coromandelica*	T	N	Economic
138.	*Leucaena leucocephala*	T	E	Economic
139.	*Limonia acidissima*	T	N	Economic
140.	*Macaranga peltata*	T	N	Economic
141.	*Madhuca butyracea*	T	N	Economic
142.	*Madhuca longifolia*	T	N	Economic
143.	*Mangifera andamanica*	T	N	Economic; Threatened
144.	*Mangifera indica*	T	N	Economic
145.	*Manilkara littoralis*	T	N	Economic
146.	*Mansoria dipikaii*	T	N	Economic
147.	*Melia azedarach*	T	N	Economic
148.	*Melia dubia*	T	N	Economic
149.	*Melicope lunu-ankenda*	T	N	Economic
150.	*Mesua ferrea*	T	N	Economic
151.	*Michelia champaca*	T	N	Economic
152.	*Miliusa tectona*	T	N	Economic
153.	*Mimusops elengi*	T	N	Economic
154.	*Mitragyna parvifolia*	T	N	Economic
155.	*Morinda citrifolia*	T	N	Economic; Threatened
156.	*Morinda tinctoria*	T	N	Economic
157.	*Morus alba*	T	N	Economic
158.	*Morus indica*	T	N	Economic
159.	*Morus laevigata*	T	N	Economic
160.	*Morus serrata*	T	N	Economic
161.	*Murraya koenigii*	T	N	Economic
162.	*Myrica wagi*	T	N	Economic
163.	*Myristica* spp.	T	N	Economic
164.	*Nauclea gaganea*	T	N	Economic
165.	*Neolamarckia cadamba*	T	N	Economic
166.	*Nothapodytes nimmoniana*	T	N	Economic
167.	*Oroxylum indicum*	T	N	Economic; Threatened
168.	*Pajanelia longifolia*	T	N	Economic
169.	*Palaquium ellipticum*	T	N	Economic
170.	*Pandanus leram*	T	N	Economic
171.	*Pandanus tectorius*	T	N	Economic
172.	*Paraserianthes falcataria*	T	N	Economic
173.	*Parishia insignis*	T	N	Economic
174.	*Paullinia* spp.	T	N	Economic
175.	*Persea macrantha*	T	N	Economic
176.	*Phoebe goalparensis*	T	N	Economic
177.	*Phoenix sylvestris*	T	N	Economic
178.	*Phyllanthus emblica*	T	N	Economic

179.	*Phyllanthus indofischerii*	T	N	Economic
180.	*Picea smithiana*	T	N	Economic
181.	*Pinus caribaea*	T	E	Economic
182.	*Pinus gerardiana*	T	N	Economic
183.	*Pinus kesiya*	T	E	Economic
184.	*Pinus oocarpa*	T	E	Economic
185.	*Pinus patula*	T	E	Economic
186.	*Pinus roxburghii*	T	N	Economic
187.	*Pinus wallichiana*	T	N	Economic
188.	*Pithecellobium dulce*	T	N	Economic
189.	*Planchonia andamanica*	T	N	Economic
190.	*Podocarpus neriifolius*	T	N	Economic; Threatened
191.	*Poeciloneuron indicum*	T	N	Economic
192.	*Pometia pinnata*	T	N	Economic
193.	*Pongamia pinnata*	T	N	Economic
194.	*Populus alba*	T	N	Economic
195.	*Populus ciliata*	T	N	Economic
196.	*Populus deltoides*	T	E	Economic
197.	*Prosopis cineraria*	T	N	Economic
198.	*Prosopis juliflora*	T	E	Economic
199.	*Prosopis pallida*	T	E	Economic
200.	*Prunus martabanica*	T	N	Economic
201.	*Pterocarpus dalbergioides*	T	N	Economic
202.	*Pterocarpus marsupium*	T	N	Economic
203.	*Pterocarpus santalinus*	T	N	Economic
204.	*Pterocymbium tinctorium*	T	N	Economic
205.	*Pterygota alata*	T	N	Economic
206.	*Quercus dialata*	T	N	Economic
207.	*Quercus griffithii*	T	N	Economic
208.	*Quercus incana*	T	N	Economic
209.	*Quercus semecarpifolia*	T	N	Economic
210.	*Quercus serrata*	T	N	Economic
211.	Rattans	O	N	Economic
212.	*Rhizophora apiculata*	T	N	Threatened
213.	*Rhizophora mucronata*	T	N	Threatened
214.	*Rhizophora stylosa*	T	N	Threatened
215.	*Rhododendron arboreum* ssp. *nilagiricum*	T	N	Threatened
216.	*Robinia pseudo-acacia*	T	N	Economic
217.	*Sagaraea elliptica*	T	N	Economic
218.	*Salix alba*	T	N	Economic
219.	*Salix tetrasperma*	T	N	Economic
220.	*Santalum album*	T	N	Economic; Threatened
221.	*Sapindus emarginatus*	T	N	Economic
222.	*Sapindus mukorossi*	T	N	Economic
223.	*Saraca asoca*	T	N	Economic; Threatened
224.	*Schleichera oleosa*	T	N	Economic
225.	*Semecarpus anacardium*	T	N	Economic

226. *Shorea robusta*	T	N	Economic
227. *Shorea roxburghii*	T	N	Economic; Threatened
228. *Sideroxylon longipetiolatum*	T	N	Economic
229. *Simarouba glauca*	T	N	Economic
230. *Sonneratia* spp.	T	N	Economic
231. *Soymida febrifuga*	T	N	Economic
232. *Spondias pinnata*	T	N	Economic
233. *Sterculia urens*	T	N	Economic
234. *Sterculia villosa*	T	N	Economic
235. *Stereospermum colais*	T	N	Economic
236. *Strychnos nux-vomica*	T	N	Economic
237. *Strychnos potatorum*	T	N	Economic; Threatened
238. *Swietenia macrophylla*	T	N	Economic
239. *Swietenia mahagoni*	T	N	Economic
240. *Syzygium cumini*	T	N	Economic
241. *Syzygium travancoricum*	T	N	Economic; Threatened
242. *Taliparitiliaceum*	T	N	Economic
243. *Tamarindus indica*	T	N	Economic
244. *Taxus baccata*	T	N	Economic; Threatened
245. *Taxus wallichiana*	T	N	Threatened, Economic
246. *Tecomella undulata*	T	N	Economic
247. *Tectona grandis*	T	N	Economic
248. *Terminalia arjuna*	T	N	Economic
249. *Terminalia bellirica*	T	N	Economic
250. *Terminalia bialata*	T	N	Economic
251. *Terminalia catappa*	T	N	Economic
252. *Terminalia chebula*	T	N	Economic
253. *Terminalia elliptica*	T	N	Economic
254. *Terminalia manii*	T	N	Economic
255. *Terminalia myriocarpa*	T	N	Economic
256. *Terminalia pallida*	T	N	Economic
257. *Terminalia paniculata*	T	N	Economic
258. *Terminalia procera*	T	N	Economic
259. *Terminalia travancorensis*	T	N	Economic
260. *Tetrameles nudiflora*	T	N	Economic
261. *Thespesia populnea*	T	N	Economic
262. *Toona ciliata*	T	N	Economic
263. *Trewia nudiflora*	T	N	Economic
264. *Vateria indica*	T	N	Economic; Threatened
265. *Vitex altissima*	T	N	Economic
266. *Wrightia arborea*	T	N	Economic
267. *Wrightia tinctoria*	T	N	Economic
268. *Xanthophyllum andamanicum*	T	N	Economic
269. *Xylia xylocarpa*	T	N	Economic
270. *Zanthoxylum budrunga*	T	N	Economic
271. *Zanthoxylum rhetsa*	T	N	Economic
272. *Zizyphus mauritiana*	T	N	Economic

Many of the forest tree species listed in Table 4 are actively managed for productive aims. While some are extracted from the natural forests many are raised in the planted forests and agroforestry systems. In the natural forests which are managed for production, the system followed is either the selection system or the shelterwood system, while the planted forests are mostly clearfelled and replanted. The details of species that are actively managed for productive aims are furnished in Table 5.

Table 5.

Forest species actively managed for productive aims in India

S. No.	Scientific names	Native (N) or exotic (E)	Current uses (code)*	If managed, type of management system (e.g. natural forest, plantation, agroforestry)	Area managed if known (ha)
1.	*Abies pindrow*	N	1, 2, 4	Natural forest, plantation	
2.	*Abies spectabilis*	E	1	Natural forest	
3.	*Acacia alata*	N	1	Plantation	
4.	*Acacia albida*	E	4,5,6 (apiculture)	Plantation, agroforestry	
5.	*Acacia aulacocarpa*	E	4	Plantation	
6.	*Acacia auriculiformis*	E	1, 2, 5	Plantation, agroforestry	564 000
7.	*Acacia catechu*	N	3,4	Plantation, Natural forest	259 500
8.	*Acacia chundra*	N	1	Natural forest	
9.	*Acacia crassicarpa*	E	1,2	Plantation	
10.	*Acacia leucophloea*	N	6 (Liquor)	Natural forest	
11.	*Acacia mangium*	E	1, 2, 5	Plantation, agroforestry	
12.	*Acacia mearnsii*	E	4	Plantation	37 500
13.	*Acacia nilotica*	N	1, 3, 4	Plantation, natural forest	801 600
14.	*Acacia occidentalis*	E	1	Plantation	
15.	*Acacia senegal*	E	1	Plantation	
16.	*Acacia tortilis*	E	4	Plantation	
17.	*Acrocarpus fraxinifolius*	N	1	Plantation	
18.	*Adenanthera pavonina*	N	1	Natural forest	
19.	*Aegle marmelos*	N	4	Natural forest	
20.	*Agalia andamanica*	N	1	Natural forest	
21.	*Ailanthus excelsa*	N	1, 4, 5	Plantation, agroforestry	
22.	*Ailanthus kurzii*	N	1	Natural forest	
23.	*Ailanthus triphysa*	N	1, 4, 5	Plantation, natural forest, agroforestry	
24.	*Albizia amara*	N	4	Natural forest	

25.	*Albizia chinensis*	N	1, 4	Natural forest	
26.	*Albizia lebbeck*	N	1, 4	Plantation	
27.	*Albizia odoratissima*	N	1, 4	Natural forest	
28.	*Albizia procera*	N	1, 2, 4	Natural forest, Plantation	
29.	*Albizia richardiana*	N	4	Plantation	
30.	*Alnus nepalensis*	N	1	Natural forest, Plantation	
31.	*Alnus nitida*	N	1	Natural forest	
32.	*Alstonia scholaris*	N	1,2,4	Natural forest, Plantation	
33.	*Amoora wallichii*	N	1	Natural forest	
34.	*Anacardium occidentale*	N	1,5	Plantation	634 900
35.	*Anogeissus latifolia*	N	1,4	Natural forest	
36.	*Antiaris toxicaria*	N	1,4	Natural forest	
37.	*Aphanamixis polystachya*	N	1	Natural forest	
38.	*Aquilaria malaccensis*	N	1	Natural forest, Plantation	
39.	*Artocarpus chaplasha*	N	1	Natural forest	
40.	*Artocarpus gomezianus ssp. zeylanicus*	N	1	Natural forest	
41.	*Artocarpus heterophyllus*	N	1, 4, 5	Plantation, natural forest, agroforestry	
42.	*Artocarpus hirsutus*	N	1	Natural forest	
43.	*Avicennia marina*	N	3	Natural forest	
44.	*Azadirachta indica*	N	1, 4, 5	Plantation, agroforestry	
45.	*Baccaurea courtallensis*	N	1	(shelter belt)	
46.	Bamboos	N	1, 2, 3, 4, 5	Plantation, natural forest, agroforestry	408 000
47.	*Barringtonia racemosa*	N	1	Natural forest	
48.	*Bauhinia purpurea*	N	1	Natural forest, Plantation	
49.	*Bauhinia racemosa*	N	1	Natural forest	
50.	*Bauhinia variegata*	N	1	Natural forest, plantation	
51.	*Bentinckia condapanna*	N	1	Natural forest	
52.	*Bischofia javanica*	N	1,2,4,6	Natural forest	
53.	*Bombax ceiba*	N	1, 4	Plantation, Natural forest, agroforestry	37 900
54.	*Bombax insigne*	N	1	Natural forest	
55.	*Borassus flabellifer*	N	1,4	Plantation, Natural forest	
56.	*Boswellia serrata*	N	1	Natural forest	
57.	*Bracantomalum mangifera*	N	1	Natural forest	

58.	*Bridelia retusa*	N	1	Natural forest	
59.	*Bruguiera sexangula*	N	1,4	Natural forest	
60.	*Buchanania lanzan*	N	1	Natural forest	
61.	*Butea monosperma*	N	1, 4	Natural forest	
62.	*Calophyllum calaba*	N	1	Natural forest	
63.	*Calophyllum inophyllum*	N	1, 3, 4	Plantation, Natural forest	
64.	*Canarium euphyllum*	N	1	Natural forest	
65.	*Canarium strictum*	N	1,4	Natural forest	
66.	*Canthium dicoccum*	N	1	Natural forest	
67.	*Caryota urens*	N	4	Natural forest	
68.	*Castanopsis indica*	N	3	Natural forest	
69.	*Castanopsis tribuloides*	N	3	Natural forest	
70.	*Cassia fistula*	N	1,4	Natural forest, Plantation	
71.	*Cassia siamea*	N	1	Natural forest	
72.	*Casuarina cunninghamiana*	E	1	Plantation	
73.	*Casuarina equisetifolia*	N	1, 2, 3, 5	Plantation, agroforestry	500 000
74.	*Casuarina junghuhniana*	E	1, 2, 3, 5	Plantation, agroforestry	
75.	*Cedrus deodara*	N	1, 3, 4	Plantation, natural forest	124 900
76.	*Celtis australis*	N	1,4	Plantation, natural forest	
77.	*Ceriops tagal*	N	1,4	Natural forest	
78.	*Chloroxylon swietenia*	N	1, 3, 4	Natural forest	
79.	*Chukrasia tabularis*	N	1	Plantation	
80.	*Cinnamomum cecidodaphnae*	N	4	Natural forest, Plantation	
81.	*Cinnamomum tamala*	N	4	Natural forest, Plantation	
82.	*Cinnamomum zeylanicum*	N	2	Natural forest, Plantation	
83.	*Cocos nucifera*	N	1,4,5	Plantation, natural forest, agroforestry	
84.	*Commiphora wightii*	N	4	Plantation	
85.	*Cordia myxa*	N	1	Natural forest	
86.	*Corypha umbraculifera*	N	1	Natural forest	
87.	*Cratoxylon formosum*	N	1	Natural forest	
88.	*Cryptocarya andersonii*	N	4	Natural forest	
89.	*Cullenia exarillata*	N	1	Natural forest	
90.	*Cupressus torulosa*	E	1	Plantation	
91.	*Dalbergia latifolia*	N	1	Plantation, natural forest	
92.	*Dalbergia sissoides*	N	1	Plantation	
93.	*Dalbergia sissoo*	N	1, 2,3,5	Plantation, natural forest, agroforestry	494 000

94.	*Dillenia indica*	N	1	Natural forest	
95.	*Dillenia pentagyna*	N	1	Natural forest	
96.	*Diospyros ebenum*	N	1, 4	Natural forest, Plantation	
97.	*Diospyros marmorata*	N	1	Natural forest	
98.	*Diospyros melanoxylon*	N	1,4	Natural forest	
99.	*Dipterocarpus* spp.	N	1	Natural forest	
100.	*Duabanga sonneratioides*	N	1	Natural forest	
101.	*Dysoxylum malabaricum*	N	1	Natural forest	
102.	*Elaeis guineensis*	E	3,4	Plantation	
103.	*Elaeocarpus tuberculatus*	N	1	Natural forest	
104.	*Endospermum chinensis*	N	1	Natural forest	
105.	*Eucalyptus* spp.	E	1, 2, 3, 5	Plantation, agroforestry	4 000 000
106.	*Evodia glabra*	N	1	Natural forest	
107.	*Ficus* spp.	N	4	Natural forest, Plantation	
108.	*Fraxinus xanthoxyloides*	N	1,2,3	Natural forest	
109.	*Ganophyllum falcatum*	N	1	Natural forest	
110.	*Garcinia gummi-gutta*	N	4	Plantation	
111.	*Garcinia indica*	N	4	Plantation	
112.	*Garcinia spicata*	N	4	Natural forest	
113.	*Garuga pinnata*	N	1	Natural forest	
114.	*Givotia moluccana*	N	1	Natural forest	
115.	*Gluta travancorica*	N	1	Natural forest	
116.	*Gmelina arborea*	N	1,5	Plantation, agroforestry	148 000
117.	*Grevillea robusta*	N	1,5	Plantation, agroforestry	
118.	*Grewia optiva*	N	1, 2, 4, 5	Natural forest, agroforestry	
119.	*Grewia tiliifolia*	N	1, 4	Natural forest	
120.	*Gyrocarpus asiaticus*	N	1	Natural forest	
121.	*Haldina cordifolia*	N	1, 2, 4	Plantation	
122.	*Hardwickia binata*	N	1	Natural forest, Plantation	
123.	*Hevea brasiliensis*	E	1,3,5,6 (apiculture)	Plantation	687 000
124.	*Hildegardia populifolia*	N	1	Natural forest	
125.	*Holoptelea integrifolia*	N	1	Natural forest	
126.	*Hopea odorata*	N	1	Natural forest	
127.	*Hopea parviflora*	N	1	Natural forest	
128.	*Hopea utilis*	N	1	Natural forest	
129.	*Jatropha curcas*	T	4	Plantation,agroforestry	
130.	*Juglans regia*	N	1,5	Natural forest,	

				agroforestry
131.	*Khaya anthotheca*	E	1,5	Plantation, Agroforestry
132.	*Khaya senegalensis*	E	1,5	Plantation, Agroforestry
133.	*Kingiodendron pinnatum*	N	1	Natural forest
134.	*Knema attenuata*	N	1	Natural forest
135.	*Kydia calycina*	N	1	Natural forest
136.	*Lagerstroemia hypoleuca*	N	1	Natural forest
137.	*Lagerstroemia microcarpa*	N	1	Natural forest
138.	*Lagerstroemia parviflora*	N	1	Natural forest
139.	*Lagerstroemia speciosa*	N	1	Natural forest
140.	*Lannea coromandelica*	N	4	Natural forest, Plantation
141.	*Leucaena leucocephala*	E	2, 3, 4, 5	Plantation, agroforestry
142.	*Limonia acidissima*	N	4	Natural forest, Plantation
143.	*Macaranga peltata*	N	1	Natural forest
144.	*Madhuca butyracea*	N	4	Natural forest
145.	*Madhuca longifolia*	N	3, 4	Plantation, natural forest
146.	*Mangifera andamanica*	N	1	Natural forest
147.	*Mangifera indica*	N	1,4	Plantation, natural forest
148.	*Manilkara littoralis*	N	1	Natural forest
149.	*Melia azedarach*	N	1	Natural forest, Plantation
150.	*Melia dubia*	N	5, 6 (Plywood)	Plantation, agroforestry
151.	*Melicope lunu-ankenda*	N	1	Natural forest
152.	*Mesua ferrea*	N	1	Natural forest
153.	*Michelia champaca*	N	1,4	Natural forest, Plantation
154.	*Miliusa tectona*	N	1	Natural forest
155.	*Mimusops elengi*	N	1	Natural forest
156.	*Mitragyna parvifolia*	N	1	Natural forest
157.	*Morinda citrifolia*	N	1, 4	Natural forest
158.	*Morinda tinctoria*	N	1	Natural forest
159.	*Morus alba*	N	4	Plantation
160.	*Morus indica*	N	4	Plantation
161.	*Morus laevigata*	N	4	Plantation
162.	*Morus serrata*	N	4	Plantation
163.	*Murraya koenigii*	N	4	Plantation, agroforestry

164.	*Myrica wagi*	N	1,5	Natural forest, Agroforestry	
165.	*Myristica* spp.	N	4	Plantation, Natural forest	
166.	*Nauclea gaganea*	N	1	Natural forest	
167.	*Neolamarckia cadamba*	N	1, 5	Plantation, agroforestry	
168.	*Nothapodytes nimmoniana*	N	1	Natural forest, Plantation	
169.	*Oroxylum indicum*	N	1	Natural forest	
170.	*Pajanelia longifolia*	N	1	Natural forest	
171.	*Palaquium ellipticum*	N	1	Natural forest	
172.	*Pandanus lerum*	N	4	Natural forest, agroforestry	
173.	*Pandanus tectorius*	N	4	Natural forest	
174.	*Paraserianthes falcataria*	N	1,5	Plantation, agroforestry	
175.	*Parishia insignis*	N	1	Natural forest	
176.	*Parkia roxburghii*	N	4	Plantation	
177.	*Paullinia* spp.	E	1,4	Plantation	
178.	*Persea macrantha*	N	4	Natural forest	
179.	*Phoebe goalparensis*	N	1	Natural forest	
180.	*Phoenix sylvestris*	N	4	Natural forest	
181.	*Phyllanthus emblica*	N	4	Plantation, natural forest, agroforestry	
182.	*Phyllanthus indofischerii*	N	4	Natural forest	
183.	*Picea smithiana*	N	1, 4	Natural forest	16 000
184.	*Pinus caribaea*	E	1, 3, 4	Plantation, natural forest	
185.	*Pinus gerardiana*	N	1, 3, 4	Plantation, natural forest	
186.	*Pinus kesiya*	E	1, 3, 4	Plantation, natural forest	127 000
187.	*Pinus oocarpa*	E	1, 3, 4	Plantation, natural forest	
188.	*Pinus patula*	E	1, 3, 4	Plantation, natural forest	
189.	*Pinus roxburghii*	N	1, 3, 4	Plantation, natural forest	318 500
190.	*Pinus wallichiana*	N	1, 3, 4	Plantation, natural forest	
191.	*Pithecellobium dulce*	N	1,4,5	Plantation, natural forest,agroforestry	
192.	*Planchonia andamanica*	N	1	Natural forest	
193.	*Podocarpus nerifolia*	N	1	Natural forest	
194.	*Poeciloneuron indicum*	N	1	Natural forest	
195.	*Pometia pinnata*	N	1	Natural forest	

196.	*Pongamia pinnata*	N	3, 4	Plantation, natural forest	
197.	*Populus alba*	E	1	Plantation	47 400
198.	*Populus ciliata*	N	1	Plantation	
199.	*Populus deltoides*	E	1	Plantation	60 000
200.	*Prosopis cineraria*	N	1	Plantation, natural forest	
201.	*Prosopis juliflora*	E	1,4	Plantation	
202.	*Prosopis pallida*	E	1,4,6 (apiculture)	Plantation	
203.	*Prunus martabanica*	N	1, 3, 4	Natural forest	
204.	*Pterocarpus dalbergioides*	N	1	Natural forest, Plantation	
205.	*Pterocarpus marsupium*	N	1, 4	Plantation, natural forest	
206.	*Pterocarpus santalinus*	N	1, 4, 5	Plantation, natural forest, agroforestry	
207.	*Pterocymbium tinctorium*	N	1	Natural forest	
208.	*Pterygota alata*	N	1	Natural forest	
209.	*Quercus dialata*	N	1	Natural forest	
210.	*Quercus griffithii*	N	1, 3	Natural forest	
211.	*Quercus incana*	N	1	Natural forest	
212.	*Quercus semecarpifolia*	N	1	Natural forest	
213.	*Quercus serrata*	N	1,3	Natural forest	
214.	Rattans	N	4	Natural forest	
215.	*Rhizophora apiculata*	N	1,3,4	Natural forest, plantation	
216.	*Rhizophora mucronata*	N	1,3,4	Natural forest, plantation	
217.	*Rhizophora stylosa*	N	1,3,4	Natural forest, plantation	
218.	*Rhododendron arboreum* ssp. *nilagiricum*	N	1, 4	Natural forest	
219.	*Robinia pseudo-acacia*	E	1	Plantation	
220.	*Sageraea elliptica*	N	1	Natural forest	
221.	*Salix alba*	N	1	Natural forest	
222.	*Salix tetrasperma*	N	1	Natural forest	
223.	*Santalum album*	N	1, 4, 5	Plantation, natural forest, agroforestry	10 500
224.	*Sapindus emarginatus*	N	1, 4	Plantation, natural forest	
225.	*Sapium baccatum*	N	1	Natural forest	
226.	*Saraca asoca*	N	4	Plantation, natural forest	
227.	*Schleichera oleosa*	N	4	Plantation, natural forest	
228.	*Semecarpus*	N	1	Natural forest	

	anacardium				
229.	*Shorea robusta*	N	1, 4	Plantation, natural forest	
230.	*Shorea roxburghii*	N	1	Plantation, natural forest	
231.	*Sideroxylon longipetiolatum*	N	1	Natural forest	
232.	*Simarouba glauca*	E	4	Plantation, agroforestry	
233.	*Sonneratia* spp.	N	1	Natural forest	
234.	*Soymida febrifuga*	N	1	Natural forest	
235.	*Spondias pinnata*	N	1	Natural forest	
236.	*Sterculia urens*	N	1,4	Natural forest	
237.	*Sterculia villosa*	N	1	Natural forest	
238.	*Stereospermum colais*	N	1	Natural forest	
239.	*Strychnos nux-vomica*	N	3,4	Natural forest	
240.	*Strychnos potatorum*	N	4	Natural forest	
241.	*Swietenia macrophylla*	N	1	Plantation, natural forest	
242.	*Swietenia mahagoni*	N	1	Plantation, natural forest	
243.	*Syzygium cumini*	N	1,4	Plantation, natural forest	
244.	*Syzygium travancoricum*	N	1	Natural forest	
245.	*Talipariti tiliaceum*	N	4	Natural forest, plantation	
246.	*Tamarindus indica*	N	1, 4, 5	Plantation, agroforestry	
247.	*Taxus baccata*	N	1, 3, 4	Natural forest	
248.	*Taxus wallichiana*	N	4	Plantation	
249.	*Tecomella undulata*	N	1	Natural forest, Plantation	
250.	*Tectona grandis*	N	1, 5	Plantation, natural forest, agroforestry	1 667 000
251.	*Terminalia arjuna*	N	1,4	Natural forest	
252.	*Terminalia bellirica*	N	1, 4	Plantation, natural forest	
253.	*Terminalia bialata*	N	1	Natural forest	
254.	*Terminalia chebula*	N	1, 4	Plantation, natural forest	
255.	*Terminalia elliptica*	N	1,4	Natural forest, Plantation	
256.	*Terminalia manii*	N	1,4	Natural forest	
257.	*Terminalia myriocarpa*	N	4	Natural forest	
258.	*Terminalia paniculata*	N	1	Natural forest	
259.	*Terminalia procera*	N	1	Natural forest	
260.	*Tetrameles nudiflora*	N	1	Natural forest	

261.	*Thespesia populnea*	N	1, 4	Plantation, natural forest
262.	*Toona ciliata*	N	1	Natural forest, Plantation
263.	*Trewia nudiflora*	N	1	Natural forest, Plantation
264.	*Vateria indica*	N	1	Natural forest
265.	*Vitex altissima*	N	1	Natural forest
266.	*Wrightia arborea*	N	1	Natural forest
267.	*Wrightia tinctoria*	N	1	Natural forest
268.	*Xanthophyllum andamanicum*	N	1	Natural forest
269.	*Xylia xylocarpa*	N	1	Plantation
270.	*Zanthoxylum budrunga*	N	1	Natural forest
271.	*Zanthoxylum rhetsa*	N	1	Natural forest
272.	*Zizyphus mauritiana*	N	4	Natural forest

*current use: 1. Solid wood products; 2. Pulp and paper; 3. Energy (fuel); 4. Non wood forest products (food, fodder, medicines, etc.); 5. Used in agroforestry systems; 6. Other

Besides the species of economic value listed in Table 5, there are a large number of tree species managed for providing environmental values or social services. There are species used in reclamation of degraded sites, as shelterbelts, in urban forestry and for soil enrichment. There are species of cultural value, of religious and social importance used by the general population as well as the tribal societies. The main forest tree species actively managed or identified for environmental services are listed in Table 6.

Table 6.

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

S.No.	Scientific names	Native (N) or exotic (E)	Environmental service or social value (code)
1.	*Abies pindrow*	N	3
2.	*Abies spectabilis*	N	3
3.	*Acacia albida*	E	2
4.	*Acacia aulacocarpa*	E	2,7 (shade tree)
5.	*Acacia alata*	N	2,5
6.	*Acacia auriculiformis*	E	2,5
7.	*Acacia catechu*	N	3
8.	*Acacia dealbata*	E	5
9.	*Acacia crassicarpa*	E	2
10.	*Acacia leucophloea*	N	2
11.	*Acacia mangium*	E	2
12.	*Acacia mearnsii*	E	2
13.	*Acacia nilotica*	N	2
14.	*Acacia occidentalis*	N	2
15.	*Acacia senegal*	E	2
16.	*Acacia chundra*	N	2

17.	*Acacia tortilis*	N	2
18.	*Acrocarpus fraxinifolius*	N	3
19.	*Adenanthera pavonina*	N	2
20.	*Aegle marmelos*	N	3,6
21.	*Agalia andamanica*	N	3
22.	*Ailanthus excelsa*	N	3
23.	*Ailanthus kurzii*	N	3
24.	*Ailanthus triphysa*	N	3
25.	*Albizia amara*	N	2,4
26.	*Albizia lebbeck*	N	2,3,4
27.	*Albizia odoratissima*	N	2
28.	*Albizia richardiana*	N	2, 5, 7 (shade tree)
29.	*Albizia procera*	N	2
30.	*Albizia chinensis*	N	2, 7 (shade tree)
31.	*Alnus nepalensis*	N	2
32.	*Alstonia scholaris*	N	5
33.	*Anacardium occidentale*	N	3
34.	*Anogeissus latifolia*	N	3
35.	*Antiaris toxicaria*	N	7 (shade tree)
36.	*Aquilaria malaccensis*	N	3
37.	*Artocarpus chaplasha*	N	3
38.	*Artocarpus heterophyllus*	N	3,4
39.	*Artocarpus hirsutus*	N	3
40.	*Artocarpus gomezianus* ssp. *zeylanicus*	N	3
41.	*Avicennia marina*	N	3,7 (shelter belt)
42.	*Azadirachta indica*	N	3,4,6
43.	*Baccaurea courtallensis*	N	3
44.	Bamboos	N	1,3,4,5,6
45.	*Bauhinia purpurea*	N	2,6
46.	*Bauhinia racemosa*	N	2,6
47.	*Bauhinia variegata*	N	2,5,6
48.	*Bischofia javanica*	N	5,7 (shade tree)
49.	*Bombax ceiba*	N	1,3,5
50.	*Bombax insigne*	N	3,5
51.	*Borassus flabellifer*	N	4
52.	*Bruguiera sexangula*	N	3,7 (shelter belt)
53.	*Butea monosperma*	N	4,5
54.	*Calophyllum calaba*	N	3
55.	*Calophyllum inophyllum*	N	3,5,6,7 (shelter belt)
56.	*Canarium euphyllum*	N	3
57.	*Canarium strictum*	N	3
58.	*Caryota urens*	N	5
59.	*Cassia fistula*	N	2,5
60.	*Cassia siamea*	N	2
61.	*Casuarina cunninghamiana*	E	2
62.	*Casuarina equisetifolia*	N	2,7(shelter belt)
63.	*Casuarina junghuhniana*	E	2,7 (shelter belt)

64.	*Cedrus deodara*	N	3,4
65.	*Celtis australis*	N	3
66.	*Ceriops tagal*	N	3, 7 (shelter belt)
67.	*Chloroxylon swietenia*	N	3
68.	*Cinnamomum cecidodaphnae*	N	3
69.	*Cinnamomum camphora*	N	5
70.	*Coccos nucifera*	N	1,4,5,6
71.	*Commiphora wightii*	N	3
72.	*Exbucklandia populnea*	N	1
73.	*Cullenia exarillata*	N	7 (food-primates)
74.	*Cupressus torulosa*	E	5
75.	*Cryptomeria japonica*	E	5
76.	*Dalbergia latifolia*	N	3,2
77.	*Dalbergia sissoides*	N	3
78.	*Dalbergia sissoo*	N	3,2
79.	*Delonix regia*	E	5
80.	*Dillenia indica*	N	5
81.	*Dillenia pentagyna*	N	1
82.	*Diospyros ebenum*	N	3,4
83.	*Diospyros marmorata*	N	1
84.	*Diospyros melanoxylon*	N	1
85.	*Dipterocarpus* spp.	N	3
86.	*Eucalyptus* spp.	E	5
87.	*Ficus* spp.	N	5,6,7 (food –avifauna)
88.	*Fraxinus xanthoxyloides*	N	3
89.	*Garcinia gummi-gutta*	N	3
90.	*Garcinia indica*	N	3
91.	*Garcinia spicata*	N	3, 7(salty areas)
92.	*Gluta travancorica*	N	3
93.	*Gmelina arborea*	N	3
94.	*Grevillea robusta*	E	1,5
95.	*Haldina cordifolia*	N	3
96.	*Hevea brasiliensis*	E	1
97.	*Hildegardia populifolia*	N	3
98.	*Hopea odorata*	N	3
99.	*Hopea parviflora*	N	3
100.	*Hopea utilis*	N	3
101.	*Jatropha curcas*	E	1
102.	*Khaya anthotheca*	E	1
103.	*Khaya senegalensis*	E	1
104.	*Kingiodendron pinnatum*	N	3
105.	*Lagerstroemia speciosa*	N	7 (shade tree)
106.	*Lannea coromandelica*	N	3
107.	*Leucaena leucocephala*	E	2
108.	*Limonia acidissima*	N	6
109.	*Madhuca butyracea*	N	3
110.	*Madhuca longifolia*	N	3,4, 5, 6
111.	*Mangifera andamanica*	N	3

112.	*Mangifera indica*	N	3,4
113.	*Nothapodytes nimmoniana*	N	3
114.	*Melia azedarach*	E	5
115.	*Melia dubia*	N	3
116.	*Melicope lunu-ankenda*	N	3
117.	*Mesua ferrea*	N	4,5
118.	*Michelia champaca*	N	4,5
119.	*Mimusops elengi*	N	4,5
120.	*Morinda citrifolia*	N	3
121.	*Murraya koenigii*	N	4
122.	*Myristica* spp.	N	3,4
123.	*Myrica nagi*	N	1
124.	*Neolamarckia cadamba*	N	3,4,5
125.	*Oroxylum indicum*	N	3,4
126.	*Pandanus lerum*	N	3,4
127.	*Pandanus tectorius*	N	3,4
128.	*Paraserianthes falcataria*	N	2,5
129.	*Paullinia* spp.	E	7 (wind break)
130.	*Persea macrantha*	N	3,4
131.	*Phyllanthus emblica*	N	3,4,5
132.	*Phyllanthus indofischerii*	N	4
133.	*Picea smithiana*	N	3
134.	*Pinus caribaea*	E	3
135.	*Pinus gerardiana*	N	3
136.	*Pinus kesiya*	E	3
137.	*Pinus oocarpa*	E	3
138.	*Pinus patula*	E	3,5
139.	*Pinus roxburghii*	N	3
140.	*Pinus wallichiana*	N	3
141.	*Pithecellobium dulce*	N	2
142.	*Pongamia pinnata*	N	3,4,5
143.	*Polyalthia longifolia*	E	5
144.	*Populus alba*	E	3
145.	*Populus ciliata*	N	3
146.	*Populus deltoides*	E	3
147.	*Prunus cerasoides*	N	5
148.	*Prosopis cineraria*	N	2,3,4,6
149.	*Prosopis juliflora*	E	2
150.	*Prosopis pallida*	E	7 (salt tolerant)
151.	*Pterocarpus dalbergioides*	N	2,3,4
152.	*Pterocarpus marsupium*	N	2,3,4
153.	*Pterocarpus santalinus*	N	2,3,4
154.	*Quercus dialata*	N	3
155.	*Quercus griffithii*	N	3
156.	*Quercus incana*	N	3
157.	*Quercus semecarpifolia*	N	3
158.	*Quercus serrata*	N	3

159.	Rattans	N	3, 4, 5
160.	*Rhizophora apiculata*	N	3, 7 (shelter belt)
161.	*Rhizophora mucronata*	N	3, 7 (shelter belt)
162.	*Rhizophora stylosa*	N	3, 7 (shelter belt)
163.	*Robinia pseudo-acacia*	E	1,2
164.	*Rhododendron arboreum* ssp. *nilagiricum*	N	3,5
165.	*Salix alba*	N	3
166.	*Salix babylonica*	E	5
167.	*Salix tetrasperma*	N	3
168.	*Santalum album*	N	3,4,6, 7 (food – avifauna)
169.	*Sapindus emarginatus*	N	3,4
170.	*Sapindus mukorossi*	N	3,4
171.	*Saraca asoca*	N	3,4,5,6
172.	*Schima walichii*	N	1
173.	*Schleichera oleosa*	N	3
174.	*Shorea robusta*	N	1,3,4
175.	*Simarouba glauca*	E	3, 7 (food –avifauna)
176.	*Sonneratia* spp.	N	3, 7 (shelter belt)
177.	*Strychnos nux-vomica*	N	7 (food –avifauna)
178.	*Strychnos potatorum*	N	3,4
179.	*Swietenia macrophylla*	N	3,4
180.	*Swietenia mahagoni*	N	3,4
181.	*Syzygium cumini*	N	3,4
182.	*Syzygium travancoricum*	N	3
183.	*Talipariti tiliaceum*	N	3,5
184.	*Tamarindus indica*	N	3,2
185.	*Taxus baccata*	N	3,5
186.	*Tecomella undulata*	N	1,3
187.	*Tectona grandis*	N	1,3,4
188.	*Terminalia arjuna*	N	4,5
189.	*Terminalia bellirica*	N	3,4
190.	*Terminalia chebula*	N	3,4
191.	*Thespesia populnea*	N	3,5, 7(shelter belt)
192.	*Toona ciliata*	N	1
193.	*Vateria indica*	N	3
194.	*Wrightia tinctoria*	N	5
195.	*Zizyphus mauritiana*	N	7 (food –avifauna, elephants)

Services and values include: 1-Soil and water conservation including watershed management; 2-Soil fertility; 3-Biodiversity conservation; 4-Cultural values; 5-Aesthetic values; 6-Religious values; 7-Other

Among the species identified as important from conservation point of view there are a large number of species that are rare, endemic, or threatened. The degree of endemism in plant species is high in India. About 11 058 species are endemic to Indian region, of which 6 200 are flowering plants. As per IUCN Red List, India has 246 globally threatened plant species, which is about 2% of the world's threatened plants (MOEF, 2009). The list of trees and woody species considered to be

threatened in all or part of their range from genetic conservation point of view is presented in Table 7.

Table 7.

List of tree and other woody forest species considered to be threatened in all or part of their range from genetic conservation point of view

S. No.	Species (Scientific name)	*Area (ha) of species' natural distribution in your country if known	Average number of trees per ha, if known	** Proportion of species, natural distribution that is in your country (%)	Distribution in the country: widespread (W), rare (R), or local	Type of threat (Code)	Threat category***		
							High	Medium	Low
1.	*Abies delavayi*	NA	NA	NA	NA	5	√		
2.	*Acer caesium*	NA	NA	NA	NA	3		√	
3.	*Acer laevigatum*	NA	NA	NA	NA	NA			
4.	*Actinodaphne lanata*	NA	NA	NA	NA	1,2,7			√
5.	*Actinodaphne lawsonii*	NA	NA	100	L	1,2,7			√
6.	*Actinodaphne salicina*	NA	NA	100	L	1,7	√		
7.	*Adinandra griffithii*	NA	NA	100	L	1	√		
8.	*Agasthiyamalaia pauciflora*	NA	NA	100	L	1,7	√		
9.	*Aglaia fusca*	NA	NA	100	R	1, 2, 7	√		
10.	*Aglaia malabarica*	NA	NA	100	L	1,2,7	√		
11.	*Ailanthus kurzii*	NA	NA	NA	NA	3		√	
12.	*Albizia arunachalensis*	NA	NA	100	L	NA			
13.	*Albizia gamblei*	NA	NA	NA	NA	5	√		
14.	*Amentotaxus assamica*	NA	NA	NA	NA	5	√		
15.	*Amoora manii*	NA	NA	100	R	1, 2, 7	√		
16.	*Anacolosa densiflora*	NA	NA	100	L	NA	NA		
17.	*Antidesma coriaceum*	NA	NA	NA	W	1, 2, 7	NA		
18.	*Antidesma tomentosum*	NA	NA	NA	W	1, 2, 7	NA		
19.	*Aporusa bourdillonii*	NA	NA	100	L	NA	NA		
20.	*Aquilaria khasiana*	NA	NA	100	L	NA	NA		
21.	*Aquilaria malaccensis*	NA	NA	NA	NA	4,5	√		
22.	*Archidendron ellipticum*	NA	NA	NA	W	1, 2, 7	NA		

23.	*Ardisia amplexicaulis*	NA	NA	100	L	1,2		√
24.	*Ardisia blatteri*	NA	NA	100	L	NA	NA	
25.	*Ardisia sonchifolia*	NA	NA	100	L	1,2	NA	√
26.	*Arenga wightii*	NA	NA	100	L	1,7		√
27.	*Artocarpus gomezianus*	NA	NA	100	R	1,2,7	NA	√
28.	*Artocarpus hirsutus*	NA	NA	100	R	3,4		√
29.	*Artocarpus peduncularis*	NA	NA	NA	W	1, 2, 7	NA	
30.	*Atuna indica*	NA	NA	100	R	NA	NA	
31.	*Atuna travancorica*	NA	NA	100	L	1,7	√	
32.	*Baliospermum calycinum* var. *micranthum*	NA	NA	NA	NA	NA	NA	
33.	*Beilschmiedia pseudomicropora*	NA	NA	NA	NA	NA	NA	
34.	*Bentinckia condapanna*	NA	NA	100	L	1,3,4,7		√
35.	*Bentinckia nicobarica*	NA	NA	100	L	1, 2, 7	√	
36.	*Bombax insigne var. polystemon*	NA	NA	100	L	1, 2, 7	√	
37.	*Boswellia ovalifoliolata*	NA	NA	NA	NA	3		√
38.	*Bridelia kurzii*	NA	NA	100	L	1, 2, 7	√	
39.	*Buchanania barberi*	NA	NA	100	L	1,2,7	√	
40.	*Buchanania sessiliflora*	NA	NA	NA	W	1, 2, 7	NA	
41.	*Byrsophyllum tetrandrum*	NA	NA	NA	W	1, 2, 7	NA	
42.	*Calophyllum kuntsleri*	NA	NA	NA	W	1, 2, 7	NA	
43.	*Calophyllum wallichianum*	NA	NA	NA	W	1, 2, 7	NA	
44.	*Canthium ficiforme*	NA	NA	100	L	NA	NA	
45.	*Capparis pachyphylla*	NA	NA	NA	NA	NA	NA	
46.	*Casearia grewiaefolia var. deglabrata*	NA	NA	NA	W	1, 2, 7	NA	
47.	*Cassine viburnifolia*	NA	NA	NA	W	1, 2, 7	NA	
48.	*Cephalotaxus griffithi*	NA	NA	NA	NA	4,5	√	
49.	*Chionanthus linocieroides*	NA	NA	100	L	NA	NA	
50.	*Cinnamomum chemungianum*	NA	NA	100	L	NA	NA	
51.	*Cinnamomum*	NA	NA	100	L	NA	NA	

	filipedicellatum								
52.	*Citrus assamensis*	NA	NA	NA	NA	NA	NA		
53.	*Citrus ichangenesis*	NA	NA	NA	NA	NA	NA		
54.	*Citrus indica*	NA	NA	NA	NA	NA	NA		
55.	*Citrus latipes*	NA	NA	NA	NA	NA	NA		
56.	*Claoxylon longipetiolatum*	NA	NA	NA	W	1, 2, 7	NA		
57.	*Cleistanthus travancorensis*	NA	NA	100	L	NA	√		
58.	*Cleistocalyx nicobaricus*	NA	NA	100	R	1, 2, 7	√		
59.	*Cochlospermum religiosum*	NA	NA	NA	NA	2,3			√
60.	*Colona javanica*	NA	NA	NA	W	1, 2, 7	NA		
61.	*Commiphora wightii*	NA	NA	NA	NA	3,4		√	
62.	*Corypha macropoda*	NA	NA	100	R	1, 2, 7	√		
63.	*Cryptocarya anamalayana*	NA	NA	100	L	NA	NA		
64.	*Cryptocarya ferrea*	NA	NA	NA	W	1, 2, 7	NA		
65.	*Cryptocarya ferrarsii*	NA	NA	100	R	1, 2, 7	√		
66.	*Cupania adenophylla*	NA	NA	NA	W	1, 2, 7	NA		
67.	*Cupania lessertiana*	NA	NA	NA	W	1, 2, 7	NA		
68.	*Cyathocalyx martabanicus*	NA	NA	NA	NA	NA	NA		
69.	*Cynometra bourdillonii*	NA	NA	100	L	1	√		
70.	*Cynometra travancorica*	NA	NA	100	R	1,7	√		
71.	*Dalbergia lanceolaria*	NA	NA	NA	NA	3,4		√	
72.	*Dimorphocalyx beddomei*	NA	NA	100	L	NA		√	
73.	*Diospyros cacharensis*	NA	NA	NA	NA	NA	NA		
74.	*Diospyros courtallamensis*	NA	NA	100	L	NA	NA		
75.	*Diospyros ebenum*	NA	NA	NA	R	1,2,7		√	
76.	*Diospyros multibracteata*	NA	NA	NA	W	1, 2, 7	NA		
77.	*Dipterocarpus alatus*	NA	NA	NA	NA	NA	NA		
78.	*Dipterocarpus bourdillonii*			100	L	1,2,7	√		
79.	*Dipterocarpus costatus*	NA	NA	NA	NA	NA	NA		

80.	*Dipterocarpus indicus*	NA	NA	100	L	1,2,7		√	
81.	*Dipterocarpus kerrii*	NA	NA	NA	W	1, 2, 4, 5,7	√		
82.	*Docynia hookeriana*	NA	NA	NA	NA	NA	NA		
83.	*Drypetes andamanica*			100	R	1, 2, 7	√		
84.	*Drypetes gardneri*	NA	NA	NA	NA	1,2,7		√	
85.	*Drypetes leiocarpa*	NA	NA	100	R	1, 2, 7	√		
86.	*Drypetes malabarica*			100	L	1,2,7	√		
87.	*Drypetes porteri*	NA	NA	NA	NA	NA	NA		
88.	*Drypetes wightii*	NA	NA	100	L	1,2,7			√
89.	*Dysoxylum beddomei*	NA	NA	100	L	1,2,7		√	
90.	*Dysoxylum reticulatum*	NA	NA	NA	NA	7	√		
91.	*Elaeocarpus acuminatus*	NA	NA	NA	R	1,7		√	
92.	*Elaeocarpus blascoi*	NA	NA	100	L	1,7	√		
93.	*Elaeocarpus macrocerus*	NA	NA	NA	W	1, 2, 7	NA		
94.	*Elaeocarpus prunifolius*	NA	NA	NA	R	1,7		√	
95.	*Endospermum chinensis*	NA	NA	NA	NA	NA	NA		
96.	*Engelhardtia wallichiana*	NA	NA	NA	NA	NA	NA		
97.	*Eugenia argentea*	NA	NA	100	L	1,2,7	√		
98.	*Eugenia discifera*	NA	NA	100	L	1,7	√		
99.	*Eugenia floccosa*	NA	NA	NA	NA	NA	NA		
100.	*Eugenia indica*	NA	NA	100	L	1,7	√		
101.	*Eugenia singampattiana*	NA	NA	100	L	1,2,7	√		
102.	*Euonymus angulatus*	NA	NA	100	L	1,7	√		
103.	*Euonymus assamicus*	NA	NA	100	L	1,7	√		
104.	*Euonymus bullantus*	NA	NA	NA	NA	NA	NA		
105.	*Euonymus paniculatus*	NA	NA	100	L	NA	NA		
106.	*Excoecaria rectinervis*	NA	NA	100	R	1, 2, 7	√		
107.	*Garcinia brevirostris*	NA	NA	NA	W	1, 2, 7	NA		
108.	*Garcinia cadelliana*	NA	NA	100	L	1, 2, 7	√		
109.	*Garcinia calycina*	NA	NA	100	R	1, 2, 7	√		
110.	*Garcinia hambroniana*	NA	NA	NA	W	1, 2, 7	NA		

111. *Garcinia imberti*	NA	NA	100	R	1,2,7		√	
112. *Garcinia kingii*	NA	NA	100	R	1, 2, 7	√		
113. *Garcinia travancorica*	NA	NA	100	L	1,2,7	√		
114. *Garcinia wightii*	NA	NA	100	L	1,2		√	
115. *Gironniera luicda*	NA	NA	NA	NA	NA	NA		
116. *Gironniera thomsoni*	NA	NA	NA	NA	NA	NA		
117. *Gleditsia assamica*	NA	NA	100	L	1,2,3,4,7		√	
118. *Glochidion andamanicum*	NA	NA	100	R	1, 2, 7	√		
119. *Glochidion bourdillonii*			100	W	1,2,7			√
120. *Glochidion pauciflorum*	NA	NA	NA	NA	NA	NA		
121. *Glochidion zeylanicum* var. *tomentosum*	NA	NA	100	L	1,2		√	
122. *Gmelina arborea* var. *canescens*	NA	NA	NA	NA	5	√		
123. *Gomphandra comosa*	NA	NA	100	R	1, 2, 7	√		
124. *Goniothalamus rhynchantherus*	NA	NA	100	L	1,2,7	NA		
125. *Gymnocaldus assamicus*	NA	NA	NA	NA	NA	NA		
126. *Homalium jainii*	NA	NA	100	L	1,2,7		√	
127. *Homalium schlichii*	NA	NA	NA	NA	NA	NA		
128. *Homalium travancoricum*	NA	NA	100	R	1,2			√
129. *Hopea erosa*	NA	NA	100	L	1,2,7	√		
130. *Hopea glabra*	NA	NA	100	L	NA	NA		
131. *Hopea helferi*	NA	NA	NA	W	1, 2, 7	√		
132. *Hopea jacobi*	NA	NA	100	L	1,2,7	√		
133. *Hopea parviflora*	NA	NA	100	R	1,7		√	
134. *Hopea ponga*	NA	NA	100	R	1,7		√	
135. *Hopea racophloea*	NA	NA	100	W	1,2,3		√	
136. *Hopea utilis*	NA	NA	100	L	1,2,3,7		√	
137. *Humboldtia bourdillonii*	NA	NA	100	L	1,2,3,7	√		
138. *Humboldtia unijuga* var. *trijuga*	NA	NA	100	L	1,7	√		
139. *Ilex gardneriana*	NA	NA	100	L	1,2,7	√		
140. *Ilex khasiana*	NA	NA	NA	NA	NA	NA		
141. *Ilex venulosa*	NA	NA	NA	NA	NA	NA		
142. *Isonandra stocksii*	NA	NA	100	R	1,2,7	√		
143. *Isonandra villosa*	NA	NA	100	R	1,2,7		√	
144. *Itea nutans*	NA	NA	NA	NA	NA	NA		
145. *Ixora lawsoni*	NA	NA	100	L	1,2,7		√	
146. *Ixora saulierei*	NA	NA	NA	NA	NA	NA		

147. *Julostylis polyandra*	NA	NA	NA	NA	NA	NA		
148. *Kingiodendron pinnatum*	NA	NA	100	L	1,2,3,7		√	
149. *Lagerstroemia hypoleuca*	NA	NA	NA	NA	1,2			√
150. *Lagerstroemia minuticarpa*	NA	NA	100	L	1,2,7	√		
151. *Litsea beddomei*	NA	NA	100	L	1,2,7	√		
152. *Litsea elongata*	NA	NA	NA	NA	NA	NA		
153. *Litsea leiantha*			100	R	1, 2, 7	√		
154. *Litsea nigrescens*	NA	NA	100	L	1, 2, 7		√	
155. *Litsea travancorica*	NA	NA	100	L	1, 2, 7		√	
156. *Lophopetalum wallichii*	NA	NA	NA	W	1, 2, 7	NA		
157. *Madhuca bourdillonii*	NA	NA	100	L	1,2,7	√		
158. *Madhuca diplostemon*	NA	NA	100	L	1,7	√		
159. *Maesa velutina*	NA	NA	NA	R	7		√	
160. *Mangifera andamanica*			100	R	1, 2, 7	√		
161. *Mangifera nicobarica*	NA	NA	100	L	NA	NA		
162. *Mastixia tetrandra*	NA	NA	NA	W	1, 2, 7	NA		
163. *Mastixia trichotoma var. maingayii*	NA	NA	NA	W	1, 2, 7	NA		
164. *Melicope indica*	NA	NA	100	L	1,2,7	√		
165. *Melicope lunu-ankenda*	NA	NA	NA	R	1,2,3	NA		
166. *Meliosma henryi* var. *mannii*	NA	NA	NA	NA	NA			√
167. *Memecylon coeruleum*	NA	NA	NA	W	1, 2, 7	NA		
168. *Memecylon excelsum*	NA	NA	NA	W	1, 2, 7	NA		
169. *Memecylon flavescens*	NA	NA	100	L	1,2,7	√		
170. *Memecylon sisparense*	NA	NA	100	L	1,7	√		
171. *Memecylon subramanii*	NA	NA	100	L	1,7	√		
172. *Mesua ferrea* var. *coromandeliana*	NA	NA	100	L	1,7		√	
173. *Mesua manii*	NA	NA	100	R	1, 2, 7	√		
174. *Michelia lanuginosa*	NA	NA	NA	R	1,3			√
175. *Michelia punduana*	NA	NA	100	L	1,3,7	√		
176. *Microtropis densiflora*	NA	NA	NA	NA	NA	NA		

177. *Miliusa nilagarica*	NA	NA	100	L	1,2,7		√	
178. *Miliusa tectona*	NA	NA	100	R	1, 2, 7	√		
179. *Mimusops andamanensis*	NA	NA	100	R	1, 2, 7	√		
180. *Morus serrata*	NA	NA	NA	NA	NA	NA		
181. *Myristica fatua* var. *magnifica*	NA	NA	100	L	1,2,7	√		
182. *Nauclea gageana*	NA	NA	100	R	1,2,7	√		
183. *Neolitsea andamanica*	NA	NA	100	R	1, 2, 7	√		
184. *Neolitsea nicobarica*	NA	NA	100	R	1, 2, 7	√		
185. *Nothopegia aureofulva*	NA	NA	100	L	1,7	√		
186. *Nothopegia beddomei* var. *wynaadica*	NA	NA	100	L	1,7	√		
187. *Ochrinauclea missionis*	NA	NA	100	R	1,2,7			√
188. *Orophea salicifolia*	NA	NA	100	R	1, 2, 7	√		
189. *Orophea thomsoni*	NA	NA	NA	NA	NA	NA		
190. *Orophea torulosa*	NA	NA	100	R	1, 2, 7	√		
191. *Orophea uniflora*	NA	NA	100	R	1,2,7			√
192. *Palaquium bourdillonii*	NA	NA	100	L	1,7			√
193. *Palaquium ravii*	NA	NA	100	L	1,7		√	
194. *Pauthrea arguta*	NA	NA	NA	NA	NA	NA		
195. *Picea spinulosa*	NA	NA	NA	NA	4,5	√		
196. *Picrasma javanica*	NA	NA	NA	NA	3		√	
197. *Pittosporum ferrugineum*	NA	NA	NA	W	1, 2, 7	NA		
198. *Pithecellobium monadelphum*	NA	NA	NA	W	1, 2, 7	NA		
199. *Pittosporum eriocarpum*	NA	NA	100	L	1,2,3,7		√	
200. *Podocarpus neriifolius*	NA	NA	NA	NA	2,3			√
201. *Polyalthia macrophylla*	NA	NA	NA	W	1, 2, 7	NA		
202. *Polyalthia rufescens*	NA	NA	100	L	1,2,7	√		
203. *Polyalthia semiarum*	NA	NA	NA	NA	NA	NA		
204. *Polyalthia shendurunii*	NA	NA	NA	NA	NA	NA		
205. *Popowia beddomeana*	NA	NA	100	L	1,2,3,7	√		
206. *Populus gamblei*	NA	NA	NA	NA	1	NA		√
207. *Prunus javanica*	NA	NA	NA	W	1, 2, 7	NA		
208. *Psychotria beddomei*	NA	NA	100	L	1,7		√	

209. *Psychotria globicephala*	NA	NA	100	L	1,2,7		√	
210. *Psychotria macrocarpa*	NA	NA	100	L	1,2,7		√	
211. *Pterocarpus santalinus*	NA	NA	100	L	3	√		
212. *Pterospermum heyneanum*	NA	NA	NA	NA	NA	NA		
213. *Rapanea striata*	NA	NA	NA	NA	NA	NA		
214. *Rhododendron dalhousiae*	NA	NA	NA	NA	1,7	√		
215. *Rhododendron johnstoneanum*	NA	NA	100	L	1,2, 4,5,7	√		
216. *Rubus lineatus*	NA	NA	NA	NA	NA	NA		
217. *Saccopetalum horsfeldii*	NA	NA	NA	W	1, 2, 7	NA		
218. *Saccopetalum tectonum (= Miliusa tectona)*	NA	NA	100	R	1, 2, 7	√		
219. *Sageraea grandiflora*	NA	NA	100	L	1,2,,7	√		
220. *Salix tetrasperma*	NA	NA	NA	NA	1,7			√
221. *Sapindus rarak*	NA	NA	NA	NA	NA	NA		
222. *Schima khasiana*	NA	NA	NA	NA	NA	NA		
223. *Scolopia kermodii*	NA	NA	NA	W	1, 2, 7	NA		
224. *Shorea roxburghii*	NA	NA	NA	NA	NA	NA		
225. *Shorea thumbaggaia*	NA	NA	NA	NA	5	√		
226. *Sophora wightii*	NA	NA	100	R	1,2		√	
227. *Sterculia macrophylla*	NA	NA	NA	W	1, 2, 7	NA		
228. *Strychnos narcondamensis*	NA	NA	100	R	1, 2, 7	√		
229. *Symplocos anamallayana*	NA	NA	100	L	1,2		√	
230. *Symplocos barberi*	NA	NA	NA	NA	NA	NA		
231. *Symplocos fasciculata*	NA	NA	NA	W	1, 2, 7	NA		
232. *Symplocos macrophylla* ssp. *rosea*	NA	NA	100	L	1,2,7		√	
233. *Symplocos monantha*	NA	NA	100	L	1,2,7		√	
234. *Symplocos nairii*	NA	NA	100	L	1,2,7		√	
235. *Symplocos oligandra*	NA	NA	100	L	1,2,7		√	
236. *Syzygium alternifolium*	NA	NA	NA	NA	NA	NA		
237. *Syzygium andamanicum*	NA	NA	100	R	1, 2, 7	√		
238. *Syzygium bourdillonii*	NA	NA	100	L	1,2,7	√		
239. *Syzygium chavaran*	NA	NA	100	L	1,2,7	√		

240. *Syzygium courtallensis*	NA	NA	100	L	1,2,7		√	
241. *Syzygium kurzii var. andamanica*	NA	NA	100	R	1, 2, 7	√		
242. *Syzygium manii*	NA	NA	100	R	1, 2, 7	√		
243. *Syzygium microphyllum*	NA	NA	NA	NA	NA	NA		
244. *Syzygium myhendrae*	NA	NA	100	L	1,2,7		√	
245. *Syzygium palghatense*	NA	NA	100	L	1,2,7	√		
246. *Syzygium parameswaranii*	NA	NA	100	L	1,2,7		√	
247. *Syzygium stocksii*	NA	NA	100	L	NA	NA		
248. *Syzygium travancoricum*	NA	NA	100	L	1,2,7	√		
249. *Taxus baccata ssp. wallichiana*	NA	NA	NA	NA	3,4	√		
250. *Tecomella undulata*	NA	NA	NA	NA	NA	NA		
251. *Terminalia pallida*	NA	NA	100	L	NA	NA		
252. *Trachycarpus takil*	NA	NA	100	L	1,7	√		
253. *Ulmus lanceaefolia*	NA	NA	NA	NA	NA	NA		
254. *Vateria indica*	NA	NA	100	W	1,7			√
255. *Vateria macrocarpa*	NA	NA	100	L	1,2,3,7	√		
256. *Vitex wimberleyii*	NA	NA	100	R	1, 2, 7	√		
257. *Wendlandia andamanica*	NA	NA	100	R	1, 2, 7	√		
258. *Wendlandia bicuspidata*	NA	NA	100	L	1,2,7		√	
259. *Wrightia coccinea*	NA	NA	NA	NA	NA	NA		
260. *Xylia dolabriformis*	NA	NA	NA	NA	NA	NA		
261. *Xylosma longifolia*	NA	NA	100	L	1,2,7		√	

NA = Data not available

Type of threat

1. Forest cover reduction and degradation
2. Forest ecosystem diversity reduction and degradation
3. Unsustainable logging
4. Management intensification
5. Competition for land use
6. Urbanisation
7. Habitat fragmentation
8. Uncontrolled introduction of alien species
9. Acidified of soil and water
10. Pollutant emissions
11. Pests and diseases
12. Forest fires
13. Drought and desertification
14. Rising sea level
15. Other

Besides the species that are known to be threatened, listed in Table 7, there are a large number of species, whose threat status is not known, due to insufficient data. The Botanical Survey of India has identified the species for which there is insufficient information to determine whether or not they are threatened. The species are *Cinnamomum heyneanum*, *Corypha umbraculifera, Cycas*

circinalis, Cycas sphaerica, Cycas zeylanica, *Diospyros ebenum, Hopea canarensis, Hydnocarpus kurzii, Magnolia griffithii, Mangifera acutigemma, Mangifera indica* (wild populations)*, Pinus bhutanica, Pterocarpus dalbergioides* and *Syzygium utilis.*

Among the priority species listed in Table 4, there are species for which domestication and breeding efforts are in progress. The initiation of tree improvement programmes has been reason for studying the intraspecific variation in many of the species. In these species, there is production and supply of Forest Reproductive Material (FRM), such as, the seeds, seedlings and ramets. Tree improvement of many of these species began in the 1960s, and is being pursued by the ICFRE and many of the SFD and Universities. The details of the programmes are discussed elsewhere in the report.

SFDs, ICFRE institutes and other research institutes handling FGRs, state Agricultural Universities and wood based industries have established SPAs, CSOs, SSOs, VMGs and modern nurseries for production of quality planting stock, in species such as, Teak, Eucalypts, Casuarinas, Acacias, Poplar, Dalbergias, Bamboos and Pines. Recently, attention towards improvement of fast growing native species and economically important indigenous species to support the TOF programme has become the priority. Conventional method of selection of CPTs with most desirable qualities and cloning of the CPTs through rooting, followed by germplasm assemblage, multilocation trials, establishment of seed orchards, VMGs, progeny testing and second generation orchards is being practiced. The novel biotechnological tools are being employed to support the breeding efforts. Novel approaches to develop hybrids in tree crops through controlled pollination, trait based selection, breeding for tailor made clones are also in progress.

A mechanism and monitoring body (Variety Release Committee) for release of clones/ varieties of forestry species has been evolved by the ICFRE. In species like *Eucalypts*, *Casuarinas* and Poplar, genetically improved elite clones have been released in the market with proper material transfer agreements with user agencies like SFDs and wood based industries. Presently, the process of registering the released clones is in progress at the MoEF. Simultaneously, DUS (Distinctness, Uniformity and Stability) descriptors have also been developed for species like *Eucalyptus*, *Casuarina*, Neem, *Pongamia* as per the guidelines of PPV & FR Act, 2001 to mark specific identity to clones and ensure the authority over the clones developed. To document forest reproductive material in the country, Certification of Forest Reproductive Material in India (Revised Scheme 1979) was prescribed by the Government of India, but is not uniformly practiced in the absence of a legal backing to the scheme (Madanagopal and Pattanath, 1979). Now the Forest Reproductive Material Certification Bill of 2008 is under consideration for enactment. At present the quantity of identified reproductive material used in forestry is negligible, and this is also one of the reasons for low productivity. The details of the seeds produced with identity and the seedling planted are at Tables 8a and 8b.

Table 8a.

Annual quantity of seeds produced and current state of identification of forest reproductive material of the main forest tree and other woody species in the country.

Species		Quantity of seeds in kg			
Scientific name	**Native (N) or Exotic (E)**	**Total quantity of seeds used**	**Quantity of seeds from documented sources (provenance/ delimited seed zones)**	**Quantity of seeds from tested provenances (provenance trials established and evaluated)**	**Quantity that is genetically improved (from seed orchards)**
Acacia auriculiformis	E	3 818	100	1 898	1 820
Acacia leucophloea	N	1 125	NA	1 125	NA
Acacia mearnsii	E	2 025	NA	1 125	900
Acacia mangium	E	2 613	50	2 563	NA
Acacia nilotica	N	15 625	NA	7 500	8 125
Acacia planifrons	N	3 750	NA	3750	NA
Acrocarpus fraxinifolius	N	NA	NA	NA	35
Albizias	E	39 050	12215	NA	3 905
Altingia excelsa	N	NA	NA	NA	15
Bambusa bambos	N	1 800	NA	1 750	50
Bombax ceiba	N	365	NA	125	295
Casuarina equisetifolia	N	988	237	195	556
Casuarina junghuhniana	E	75	NA	15	60
Chukrasia tabularis	N	27	NA	NA	27
Dalbergia sissoo	N	6 499	NA	1 560	4 939
Eucalyptus camaldulensis	E	224	8	62	154
Eucalyptus globulus	E	120	NA	120	NA
Eucalyptus grandis	E	630	NA	630	NA
Eucalyptus pellita	E	80	80	NA	NA
Eucalyptus urophylla	E	4	2	NA	2
Eucalyptus tereticornis	E	2 440	4	21	2 415
Gmelina arborea	N	52 088	NA	788	51 780
Michelia champaca	N	88	NA	NA	88
Pinus caribaea	N	25	25	NA	NA

Phoebe goalparensis	N	40	NA	NA	40
Tectona grandis	N	3 690 183	NA	2 323 650	1 366 891
Terminalia myriocarpa	N	75	NA	NA	75

NA- Data not available

Table 8b.

Annual number of seedlings (or vegetative propagules) planted and the state of identification of the reproductive material used for the main forest tree and other woody species in the country.

Species		Total quantity of seedlings planted	Quantity of seedlings from documented sources (provenance/ delimited seed zones)	Quantity of seedlings from tested provenances (provenance trials established and evaluated)	Quantity of vegetative reproductive material used	Quantity of seedlings that are genetically improved
Scientific name	**Native (N) or Exotic (E)**					
Acacia auriculiformis	E	200 000	NA	200 000	NA	NA
A.auriculiformis X A.mangium hybrid	N	3 000 000	--	--	3 000 000	--
Artocarpus chaplasha	N	11 000	NA	NA	NA	NA
Bambusa balcooa	N	74 000	NA	NA	74 000	NA
Bambusa nutans	N	22 200	NA	NA	22 200	NA
Bambusa tulda	N	4 000	NA	NA	4 000	NA
Calamus spp.	N	23 000	NA	NA	NA	NA
Calophyllum inophyllum	N	4000	NA	NA	NA	NA
Casuarina equisetifolia	N	3 801 600	15 000 000	NA	16 000	3 000 000
Casuarina equisetifolia x junghuhniana hybrid	E	5 637 803	--	--	5 607 803	30 000
Dendrocalamus asper	N	4 000	NA	NA	4,000	NA
Diospyros marmorata	N	2,000	NA	NA	NA	NA
Dipterocarpus spp.	N	8,000	NA	NA	NA	NA
Eucalyptus camaldulensis	E	28 942 797	200 000	1 10 000	27 429 482	103 315

Eucalyptus tereticornis	E	2 253 823	100 000	2 000	2 150 823	1 000
Eucalyptus pellita	E	1 200 000	NA	1 200 000	NA	NA
Eucalyptus urophylla	E	100 000	NA	100 000	NA	NA
Eucalyptus urophylla x E. grandis	E	40 000 000	--	--	40 000 000	--
Hevea brasiliensis	E	16 400 000	--	--	16 400 000	--
Hopea odorata	N	15 000	NA	NA	NA	NA
Lagerstroemia hypoleuca	N	3 000	NA	NA	NA	NA
Manilkara littoralis	N	16 000	NA	NA	NA	NA
Pajanelia longifolia	N	17 000	NA	NA	NA	NA
Pandanus spp.	N	14 000	NA	NA	NA	NA
Planchonia andamanica	N	10 000	NA	NA	NA	NA
Podocarpus nerifolia	N	3 000	NA	NA	NA	NA
Pterocarpus dalbergioides	N	20 000	NA	NA	NA	NA
Terminalia bialata	N	8 000	NA	NA	NA	NA
Terminalia manii	N	3 500	NA	NA	NA	NA
Terminalia procera	N	39 000	NA	NA	NA	NA

NA- Data not available; -- Seedlings not used.

The Government of India has plans to establish an NBFGR and as a precursor to that an FGRMN has been established in 2011 under ICFRE with its nodal centres at IFGTB, Coimbatore and FRI, Dehradun. The FGRMN has the mandate to act as nodal agency at national level for acquisition and management of indigenous and exotic forest genetic resources for their exploration, documentation, conservation and their sustainable utilization.

The FGRMN has been established with the objectives to plan, prioritize, organize, conduct and coordinate exploration, collection and documentation of indigenous and exotic forest genetic resources to strengthen *in situ* and *ex situ* conservation. It shall also undertake introduction, exchange and quarantine of genetic resources of forest origin. It shall characterize, evaluate and conserve forest genetic resources and ensure their sustainable management in collaboration with state forest departments, ICFRE institutes, other national organizations, research institutes, universities, industries and NGOs. In this process a large number studies would be undertaken to understand the intraspecific diversity of the economically important species and those of conservation importance. The FGRMN will also be required to develop and maintain a national

information network on FGR, develop genomic tools, techniques and approaches to characterize and validate the germplasm and conduct research, teaching and generation of public awareness on FGRs. The details of economically important species for which the genetic variability has been evaluated are at Table 9.

Table 9.

List of forest species for which genetic variability has been evaluated

S. No.	Scientific names	Native (N) or exotic (E)	Morphological traits	Adaptive and production characters assessed	Molecular characterization
1.	*Acacia auriculiformis*	E	Bark, phyllode, inflorescence and seed traits.	Biomass, Volume, Density	RAPD
2.	*Acacia catechu*	N	Seed and seedling traits	NA	RAPD
3.	*Acacia mangium*	E	Bark, phyllode, inflorescence and seed traits.	Biomass, Volume , Density, Pulp yield, Lignin, hemicelluloses	RAPD
4.	*Acacia mearnsii*	E	NA	Pulp, tannin	NA
5.	*Acacia nilotica*	N	Seed and seedling traits	Pest resistance	RAPD, actin gene partial sequence, Isozymes.
6.	*Acacia senegal*	E	Seed and pod traits	Biomass	RAPD
7.	*Adenanthera pavonina*	N	NA	NA	RAPD
8.	*Aegle marmelos*	N	Fruit and seed traits		Isozyme
9.	*Ailanthus excelsa*	N	NA	Biomass, Volume	RAPD
10.	*Albizia amara*	N	Leaf, Seed and pod traits	NA	AFLP
11.	*Albizia lebbeck*	N	Seed and pod traits	NA	AFLP
12.	*Albizia odoratissima*	N	Leaf, Seed and pod traits	NA	AFLP
13.	*Albizia procera*	N	Leaf, Seed and pod traits	NA	AFLP
14.	*Anacardium occidentale*	E	Fruit and nut traits	NA	RAPD, ISSR
15.	*Aquilaria malaccensis*	N	NA	Agar oil	NA
16.	*Artocarpus heterophyllus*	N	Fruit traits	Clear bole	RAPD, Isozymes
17.	*Azadirachta indica*	N	Leaf, fruit, seed traits	Oil, azadiractin, Volume	RAPD, Isozymes, AFLP, SAMPL
18.	Bamboos	N	NA	Volume, density, Pulp	RAPD, AFLP, ISSR, EST

				yield, Lignin, hemicellulose, Silica	
19.	*Bambusa bambos*	N	NA	NA	RAPD
20.	*Bambusa tulda*	N	NA	NA	RAPD
21.	*Bauhinia purpurea*	N	Fruit, seed traits	Seed yield	RAPD
22.	*Bauhinia variegata*	N	Seedling traits	Biomass	RAPD
23.	*Bombax ceiba*	N	Seed and Seedling traits	NA	NA
24.	*Bruguiera cylindrica*	N	NA	NA	RAPD
25.	*Bruguiera gymnorrhiza*	N	NA	NA	RAPD
26.	*Bruguiera parviflora*	N	NA	NA	RAPD
27.	*Bruguiera sexangula*	N	NA	NA	RAPD
28.	*Buchanania lanzan*	N	Fruits, kernel traits	Biochemical studies	NA
29.	*Butea monosperma*	N	NA	NA	RAPD
30.	*Calophyllum inophyllum*	N	Fruits, seeds traits	Oil	NA
31.	*Canarium strictum*	N	Seed traits	Resin	NA
32.	*Cassia fistula*	N	Seed traits	Phytochemicals	Isozymes, RAPD, ISSR and SSR
33.	*Casuarina equisetifolia*	N	Inflorescence, Cone, Seed and Seedling traits	Biomass, Volume, Salt tolerance, wood density, Pulp yield, Lignin, hemicellulose, disease resistance	ISSR, RAPD, SSR, gene partial sequence of NHX1
34.	*Casuarina junghuhniana*	E	Inflorescence, Cone, Seed and Seedling traits	Biomass Basic density, Pulp yield, Lignin, hemicelluloses	ISSR
35.	*Cedrus deodara*	N	Seed and Seedling traits	Oil	Isozymes, RAPD, ISSR, SSR
36.	*Ceriops decandra*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
37.	*Ceriops tagal*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
38.	*Cinnamomum camphora*	N	NA	NA	RAPD
39.	*Cinnamomum aromaticum*	N	NA	NA	RAPD
40.	*Cordia myxa*	N	Leaf, fruit characters and pulp:stone ratio	Yield	RAPD
41.	*Cynometra ramiflora*	N	NA	NA	RAPD
42.	*Dalbergia latifolia*	N	Seed and seedling		RAPD

			traits		
43.	*Dalbergia sissoides*	N	NA	NA	RAPD
44.	*Dalbergia sissoo*	N	Seed and seedling traits		Isozymes, RAPD
45.	*Dalbergia spinosa*	N	NA	NA	RAPD
46.	*Dendrocalamus strictus*	N	NA	NA	RAPD
47.	*Diospyros melanoxylon*	N	Leaves, Fruits	NA	NA
48.	*Dysoxylum malabaricum*	N	NA	NA	SSR
49.	*Dysoxylum binectariferum*	E	NA	NA	SSR
50.	*Elaeis guineensis*	E	NA	Oil	RAPD
51.	*Eucalyptus* spp.	E	Inflorescence, Fruit, Seed and Seedling traits	Biomass, pulp Basic density, Pulp yield, Lignin, hemicellulose, gall insect resistance	ISSR, AFLP RAPD, SSR, gene partial sequence of HKT1, NHX1, actin.
52.	*Garcinia indica*	N	Vegetative, floral and fruiting characters	Yield	RAPD
53.	*Ginkgo biloba*	N	NA	NA	AFLP, SSR
54.	*Gmelina arborea*	N	Leaf, fruit, seeds and flowers	Volume, Basic density, Wood anatomy, Pulp yield, Lignin, hemicellulose	RAPD, ISSR, Isozymes
55.	*Guadua angustifolia*	N	NA	NA	RAPD, ISSR
56.	*Hardwickia binata*	N	Pod and seed traits	Wood density	RAPD
57.	*Hevea brasiliensis*	E	NA	Latex, wood properties	RAPD, ISSR
58.	*Jatropha curcas*	E	Seeds, flowers, fruits	Oil	RAPD, AFLP, RFLP, SSR, Isozymes
59.	*Kandelia candel*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
60.	*Leucaena leucocephala*	E	Pod and seed traits	Fodder, pulp	RAPD, ISSR, SSR, CCoAOMT, Family 1 Glycosyl hydrolase, CCR genes
61.	*Madhuca longifolia*	N	Seeds, flowers, fruits	Oil	RAPD
62.	*Melia dubia*	N	Fruit and seed traits	NA	NA
63.	*Morinda citrifolia*	N	NA	NA	RAPD, ISSR
64.	*Morinda tinctoria*	N	NA	NA	RAPD, ISSR
65.	*Morinda pubescens*	N	NA	NA	RAPD, ISSR
66.	*Morus alba*	N	Phenology, seed, inflorescence, leaf pod, seed and	NA	RAPD

			seedling traits		
67.	*Morus indica*	N	Phenology, seed, inflorescence, leaf pod, seed and seedling traits	NA	RAPD
68.	*Morus laevigata*	N	Phenology, seed, inflorescence, leaf pod, seed and seedling traits	NA	RAPD
69.	*Morus serrata*	N	Phenology, seed, inflorescence, leaf pod, seed and seedling traits	NA	RAPD
70.	*Myristica malabarica*	N	NA	NA	SSR
71.	*Neolamarckia cadamba*	N	Seed and seedling traits	NA	RAPD
72.	*Poeciloneuron pauciflorum*	N	NA	NA	RAPD
73.	*Phyllanthus emblica*	N	Fruit and seed variation	Ascorbic acid, fruit yield	RAPD, ISSR
74.	*Pinus roxburghii*	N	Cone, seed and seedling traits	Biomass	Isozyme , RAPD, ISSR, AFLP, SSR
75.	*Pinus wallichiana*		Cone, seed and seedling traits	NA	Isozyme , RAPD, ISSR, AFLP, SSR
76.	*Pithecellobium dulce*	N	Pod and seed traits	NA	RAPD
77.	*Pongamia pinnata*	N	Phenology, seed, inflorescence, leaf pod, seed and seedling traits	Oil, fatty acids, terpenoids and flavanoids	RAPD, ISSR and AFLP, actin gene partial sequence.
78.	*Populus alba*	N	Leaf pod, seed and seedling traits	Biomass, volume	Repetitive DNA elements
79.	*Populus ciliata*	N	NA	Biomass, Volume, Wood properties	RAPD, Repetitive DNA elements
80.	*Populus deltoides*	E	Leaf	Biomass, Volume, Wood properties	AFLP, Repetitive DNA elements
81.	*Prosopis cineraria*	N	Pod and seed traits	Biomass, Volume, Wood properties	RAPD, ISSR
82.	*Prosopis juliflora*	E	Pod and seed traits	Salt tolerance, drought tolerance	RAPD, ISSR, Actin, GST and MT genes, MT1,2,3, LEA promoters, transcript-tion factors
83.	*Pterocarpus marsupium*	N	Phenology, Leaf, Pod, Bark and seed traits	NA	NA
84.	*Pterocarpus santalinus*	N	Bark, Leaf traits	Timber,	RAPD

				Santalin	
85.	*Rhizophora apiculata*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
86.	*Rhizophora mucronata*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
87.	*Rhizophora lamarckii*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
88.	*Rhizophora x lamarckii*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
89.	*Rhizophora stylosa*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
90.	*Rhizophora annamalayana*	N	NA	NA	Isozymes, RAPD, RFLP, cp DNA, mtDNA
91.	*Santalum album*	N	Leaf, flower, fruit and seed traits	Disease resistance, oil	ISSR, RAPD, Isozyme
92.	*Sapindus emarginatus*	N	Fruit and seed traits	Saponins	NA
93.	*Semecarpus kathalekanensis*	N	NA	NA	SSR
94.	*Simarouba glauca*	N	NA	NA	Isozyme, RAPD
95.	*Swietenia mahagoni*	N	Fruit traits	NA	NA
96.	*Syzygium cumini*	N	Fruit and seed traits	Physicochemical evaluation of fruits	RAPD
97.	*Tamarindus indica*	N	Fruit, seeds, flowers,	Tartaric acid, fruit yield	Isozymes, RAPD
98.	*Taxus wallichiana*	N	NA	Taxol	RAPD
99.	*Tecomella undulata*	N	Leaf and flower parts, fruit and seed traits	Biomass	RAPD, AFLP, SSR
100.	*Tectona grandis*	N	Fruit and seed traits	Biomass, Volume, wood traits, insect pest resistance	RAPD, AFLP, ISSR and Isozyme
101.	*Terminalia arjuna*	N	Fruits and leaves	NA	RAPD, AFLP
102.	*Terminalia bellirica*	N	Fruits and leaves	NA	RAPD, Isozymes, ISSR
103.	*Terminalia chebula*	N	Fruits and leaves	NA	RAPD, Isozymes, ISSR
104.	*Ziziphus mauritiana*	N	Fruits	NA	NA

1.3 Factors influencing the state of forest genetic diversity in India

The relative importance of the main forest tree species being utilized has changed over the past ten years because of economic development, relaxation in import of finished products, access to global markets, invention of new products, attitudinal change in society, legal provisions and environmental awareness. Therefore, the species that are in demand for economic use are changing. There is an increased emphasis on short rotation species, as the farmers who plant the trees in agroforestry systems expect quick returns on investment. The demand for structural timber, usually from the long rotation species, is partially met by the import of timber and finished wood products.

Genetic erosion is not of much concern, as timber extraction from natural forests is limited. Most of the timber requirement is met from the planted forests. However, whenever required assessment of genetic erosion is done. For instance, recently the status of *Pterocarpus santalinus* was assessed to address issues related to its international trade, restricted by the CITES. Similarly *Santalum album* is another candidate which has been proposed for assessment. However co-ordinated approach of assessing the genetic erosion of important forest tree species on regular basis needs attention in the country.

Some of the ecosystems that are threatened in the country are sholas, wetlands, coral reefs and mangroves. Most of the causative factors for threats are overexploitation, habitat loss, fragmentation and forest fires. The species that are located in those ecosystems suffer the threat of genetic erosion. Periodic and project based assessment of threatened species are implemented based on the financial support available. Some of the mechanisms used for monitoring genetic erosion and vulnerability are establishment of permanent preservation plots, medicinal plant conservation area and species specific periodic assessment for the regeneration status, frequency and distribution in endemic areas or country wide as the case may be for important species.

Generally the option for preventing and correcting genetic erosion and vulnerability of a particular species is through genetic augmentation programmes in which infusions are introduced from within the country or abroad to broaden the genetic base, especially for exotics. However care has to be taken to ensure that in case of native species, the original diversity existing in a species is not hampered to an alarming rate that the purity of the species is lost. Proper analysis of existing genetic base has to be made prior to introductions and prevalence of sub-species level changes also needs to be ensured through molecular studies. Simultaneously the original native entities which are in the process of genetic erosion could be conserved with identity in isolated areas in the form of clonal repositories, seed banks, *in vitro* or cryo gene banks.

To improve FGR disaster response mechanism, the country needs to prioritise FGR to work on in a phased manner, prepare the species distribution maps, construct specieswise baseline data on diversity, pool existing data to prepare a common reference document, build expertise through sufficient training and capacity building programmes, develop countrywide network of working groups, launch programmes with financial support or self-sustaining programmes, create public awareness to stay with preparedness and involve community in these activities.

1.4 Future needs and priorities

The forest departments, research institutes and other stakeholders handling the FGR in association with other government departments have to contribute to management and conservation of FGRs through an integrated approach. The areas that need urgent attention in the matter of biodiversity conservation including FGR conservation and management are: i) integrated database development at all organizational and management levels, to effectively utilize the data for decision making and establishment of a national information system, ii) skill development at all levels, especially related to new biotechnologies, benefit sharing mechanisms, tools in monitoring biodiversity including FGR diversity, iii) encouraging taxonomy related research, iv) monitoring and assessing biodiversity for representative landscapes on long term continous basis, v) climate change and FGR related research, vi) elimination of invasive alien species, that threaten the diversity, vii) incentives for sustainable utilization of resources and viii) sustained research on genetic diversity (MOEF, 2009). Recently the Ministry of Environment and Forests has agreed to establish an Environment Information System ENVIS for FGR at IFGTB and this will fulfill the need for integrated database development and establishment of a national information system.

A National seed procurement and distribution system, as envisaged earlier in the Certification of Forest Reproductive Material in India, (Revised scheme, 1979) has to be in place to coordinate, regulate and support tree planting activities in India, using improved planting stock. The passing of the Forest Reproductive Material Certification Bill, 2008 and its early enactment would pave way for use of improved planting stock in the plantation programmes of the country, and thus for improved productivity.

In order to take up all the abovesaid activities, increased funding is required. Besides funding, the existing strength of scientific manpower in forestry sector needs to be augmented through large-scale recruitment. The available manpower also should be strengthened in research capabilities through capacity building efforts. Networking of agencies involved in FGR management would help eliminate duplication of work and strengthen the ongoing works of conservation and sustainable use of FGR.

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CHAPTER 2

THE STATE OF *IN SITU* GENETIC CONSERVATION

2.1 Forest genetic resource inventories and surveys

In order to know the exact status of Forest Genetic Resources and requirement of conservation measures, resources inventories and survey are essential. However in India, resource surveys have been carried out in the past mainly to document the availability of resources, by the Pre-investment Resource Surveys, now converted to FSI, which assesses the forest cover on two-year cycle and publishes the information in the form of a State of Forest Report (SFR) using satellite data and ground truthing. It helps in monitoring changes in the cover, estimation of growing stock, annual increment, species composition, bio-diversity, non-timber forest products, etc. However, the FSI is able to assess only the forest cover for the whole country, and the assessment of other parameters is done only for specific areas/ purposes.

The BSI regularly makes assessment of the threatened plant species including FGR, based on the survey and exploration as well as herbarium and literature studies. About 1 500 species of flowering plants and few hundreds of Pteridophytes, Bryophytes, Lichens and Fungi have been identified as threatened. After careful and critical evaluation of their status and threat perceptions, data sheets on 1 182 species have been prepared out of which account of 708 species have already been published as Red Data Book of Indian Plants (Nair and Sastry, 1987; 1988; 1990). Foundation for Revitalization of Local Health Traditions (FRLHT), Bangalore with the collaboration of forest departments and several other research organizations and individuals has assessed the threat status especially of medicinal pants. As per the IUCN Red List of 2008, India has 246 globally threatened floral species, which constitute approximately 3 % of the world's total number of threatened floral species. IUCN has listed different categories of threatened species including globally threatened. There are 364 species falling in the following categories: Extinct- 7; Extinct in wild-2; Critically endangered-45; Endangered- 113; Vulnerable- 89; Lower-risk Conservation dependent- 1; Lower risk Near threatened- 22; Data deficient- 18 and Lower risk- Least concern- 68.

2.2. Conservation of forest genetic resources within and outside protected areas

2.2.1. Conservation within protected areas

In order to conserve whole variability within and among different species, Protected Areas (PAs) have been established. India has created a network of PAs which includes 667 units (102 National Parks, 514 Wildlife Sanctuaries, 47 Conservation Reserves and 4 Community Reserves). Besides these there are 25 wetlands declared as Ramsar sites and 15 areas in different biogeographic zones declared as Biosphere Reserves. The extent of PA network is around 157 826.773 sq. km over 4.8 %

of the land area. The National Wildlife Action Plan envisages increase of this to 10% of the land area. The conservation of biodiversity within the PA network takes care of the FGRs also.

The PAs in India are mainly meant for large mammals, birds and some specific conservation dependant species. However, when the whole habitat or ecosystems are protected, whole plant genetic resources also enjoy the protection. No specific PAs are designated for the conservation of FGR, except for some of the plant species, established recently in view of the importance of certain species in the ecosystem. They are Kurinjimala National Park, Idukki district, Kerala for *Strobilanthes*, the *Rhododendron* Sanctuary at Singba in Sikkim, the *Nepenthes s*anctuary at Jarain and National Citrus Gene Sanctuary in Meghalaya, and the orchid sanctuary at Sessa in Arunachal Pradesh.

Different works of evaluation of genetic conservation of forest trees and woody species in the country have been carried out. Rao *et al.* (2001) assessed the genetic diversity of sandal (*Santalum album*) populations of peninsular India and suggested that *in-situ* conservation of sandal genetic resources has to focus on populations and sites in the Deccan plateau. Similarly, Ravikanth *et al.* (2001) mapped the genetic diversity of rattans in central Western Ghats and suggested to have conservation stands at three sites in Southern Western Ghats. Anandarao (2003) and Tikader *et al*. (2001) studied the germplasm of different species of *Morus* and identified diverse populations in different locations in Andamans and North- East India. Padmini *et al.* (2001) analyzed genetic diversity of *Phyllanthus emblica* in forests of South India and identified different locations with high diversity for *in-situ* conservation. However, these findings could not be utilized fully as certain identified sites fall outside the already established PAs**.** Vasudeva *et al* (2002) studied the available population of *Semecarpus kathalekanensis* an endangered tree and its diversity in *Myristica* swamp in Karnataka and suggested the requirement of special *in-situ* conservation measures.

2.2.2. Conservation outside protected areas

In addition to the PAs, there are several other means of *in-situ* conservation like Sacred Groves (SG), Gene Pool Conservation Areas (GPCA), Medicinal Plant Conservation Areas (MPCA), Seed Production Area (SPA) and Permanent Preservation Plots (PPP). Sacred groves are patches of natural vegetation, which are protected through some religious faiths and exist throughout the country. They shelter many economically important, medicinal, endemic, rare and endangered species. Extent of sacred groves varies from 10 m^2 to 1 000 000 m^2. Although, there has been no comprehensive study on the sacred groves of the entire country, experts estimate the total number of sacred groves in India could be in the range of 100 000 – 150 000. (Malhotra *et al*. 2001; Kunhikannan and Singh, 2005; Warrier *et al*. 2008)

Some SFDs like that of Kerala, Tamil Nadu and West Bengal have established GPCA providing specific protection to those areas by local people through participatory approaches. These are large areas of great genetic diversity, outside the PA network. In order to obtain quality seeds for planting, SPA have been established within forests, for many species, and these areas serve the purpose of conservation as well as seed production for increasing the productivity of the species. There are also a large number of preservation plots and sample plots established as early as 1905, for the purpose of preserving sample ecosystems or populations of species, for long term observation. There are about 309 preservation plots throughout the country, 187 in natural forests and 122 in plantations covering a total area of about 8 500 ha. Status of the preservation plot is monitored regularly for plant succession and crop dynamics. Efforts are on to establish more

preservation plots. There are also a large number of plus trees located within the forest areas, which are preserved. The details of different species included within the *in situ* conservation programmes are provided in Table 10.

Table 10.

Target forest species included within *in situ* conservation programmes/ units

Species (scientific name)	Purpose for establishing conservation unit	Number of populations or stands conserved	Total Area (Ha)
1. *Abies pindroa*	Seed production	1	13.25
2. *Acacia catechu*	Seed production	14	230.00
3. *Acacia nilotica*	Seed production	7	87.00
4. *Acrocarpus fraxinifolius*	Seed production	1	2.00
5. *Adina cordifolia*	Seed production	1	255.00
6. *Aegle marmelos*	Seed production	1	0.50
7. *Ailanthus excelsa*	Seed production	1	10.00
8. *Ailanthus triphysa*	Seed production	1	7.00
9. *Albizia amara*	Seed production	1	2.00
10. *Amoora wallichii*	Seed production	1	11.00
11. *Anogeissus latifolia*	Seed production	5	57.00
12. *Artocarpus chaplasha*	Seed production	1	2.00
13. *Artocarpus heterophyllus*	Seed production	2	5.00
14. *Bombax cieba*	Seed production	7	51.50
15. *Borassus flabellifer*	Seed production	1	30.00
16. *Buchanania lanzan*	Seed production	1	20.00
17. *Calophyllum inophyllum*	Seed production	1	315.00
18. *Cedrus deodara*	Seed production	6	86.80
19. *Chloroxylon swietenia*	Seed production	1	10.00
20. *Chukrasia tabularis*	Seed production	4	29.00
21. *Cupressus torulosa*	Seed production	1	5.00
22. *Dalbergia latifolia*	Seed production	5	37.30
23. *Dalbergia sissoo*	Seed production	19	197.00
24. *Dalbergia sissoo*	To study natural succession	2	2.00
25. *Diospyros melanoxylon*	Seed production	1	5.00
26. *Dipterocarpus macrocarpus*	Seed production	5	39.00
27. *Dipterocarpus retusus*	Seed production	2	16.00
28. *Dipterocarpus turbinatus*	Seed production	1	2.00
29. *Ficus* spp.	Seed production	2	8.00
30. *Garcinia indica*	Seed production	1	78.00
31. *Gmelina arborea*	Seed production	7	59.50
32. *Hardwickia binata*	Seed production	7	80.40
33. *Hopea parviflora*	Seed production	4	50.70
34. *Lagerstroemia lanceolata*	Seed production	2	8.30

35. *Limonia acidissima*	Seed production	2	3.50
36. *Madhuca longifolia* var. *latifolia*	Seed production	1	10.00
37. *Michelia champaca*	Seed production	1	1.00
38. *Mitragyna parvifolia*	Seed production	1	5.00
39. *Morinda tinctoria*	Seed production	1	10.00
40. *Morus laevigata*	Seed production	1	1.00
41. *Pinus caribaea*	Seed production	2	6.00
42. *Pinus kesiya*	Seed production	1	15.00
43. *Pinus patula*	Seed production	1	1.50
44. *Pinus roxburghii*	Seed production	17	215.00
45. *Pinus wallichiana*	Seed production	5	87.00
46. *Prosopis cineraria*	Seed production	1	10.00
47. *Pterocarpus dalbergioides*	Seed production	1	29.11
48. *Pterocarpus marsupium*	Seed production	5	57.00
49. *Pterocarpus santalinus*	Seed production	2	32.40
50. *Pterospermum acerifolium*	Conservation and study of natural succession in this type of forest	1	3.70
51. *Rhododendron arboreum*	Seed production	1	0.50
52. *Santalum album*	Seed production	6	32.60
53. *Schleichera oleosa*	Seed production	1	5.00
54. *Semecarpus anacardium*	Seed production	1	186.00
55. *Shorea robusta*	Seed production	9	501.80
56. *Shorea robusta*	Preservation of high quality sal crop	6	75.00
57. *Sterculia villosa*	Seed production	1	4.00
58. *Swietenia mahagoni*	Seed production	1	10.00
59. *Tachycarpus takil*	Conservation of rare palm species endemic to Kumaon hills	1	10.00
60. *Tamarindus indica*	Seed production	1	5.00
61. *Taxus baccata*	Conservation	16	89.00
62. *Tectona grandis*	Seed production	223	6 014.34
63. *Terminalia alata*	Seed production	6	51.74
64. *Terminalia bellirica*	Seed production	1	67.00
65. *Terminalia chebula*	Seed production	1	5.00
66. *Terminalia myriocarpa*	Seed production	1	5.00
67. *Vateria indica*	Seed production	1	4.00
68. *Xylia xylocarpa*	Seed production	1	33.00
69. *Ziziphus mauritiana*	Seed production	2	14.50
70. *Haldina cordifolia, Albizzia procera, Shorea robusta, Diospyros embroptria, Terminalia bellirica*	To preserve an area of primeval fresh water swamp forest.	4	57.00
71. Medicinal plants Conservation	General conservation and	54	6500.00

	Areas	supplementing *ex-situ* conservation		
72.	Permanent Preservation Plots	To conserve natural populations of important forest trees and representative forest types	187	8 500

2.3 Conservation of Bamboo Genetic Resources

India is the 2nd richest country in bamboo genetic resources. Nearly 8 957 500 ha of forest area is occupied by bamboos. The main bamboo species are *Bambusa bambos, B. balcooa, B. pallida, B. tulda, B. polymorpha, Dendrocalamus hamiltonii, D. longispathus, D. strictus, Melocanna bambusoides, Oxytenanthera nigrociliata, O. parviflora, Pseudostachys polymorphium* and *Polystachya pergracile*. Large forest areas have been declared as National Bamboo Reserves and maintained. Considering the limitation in seed supply, vegetative methods for *ex situ* conservation and tissue culture work have been started in Asian countries. National Bamboo Mission has been launched by the Ministry of Agriculture for bringing more areas under bamboos. National Mission on Bamboo Applications (NMBA), focuses on wood substitutes and composites, construction & structural applications, agro-processing, machinery & process technologies, propagation & cultivation, industrial products and product applications in bamboos. A National Mission on Bamboo Technology & Trade Development was established, considering its role in rural economy and poverty alleviation and potential use in handicrafts and industrial development. A Bamboo Information Centre established at KFRI, Peechi disseminates information on 137 species of Indian bamboo. There is a recently established Advanced Research Centre for Bamboo and Rattan at Aizawl, by the ICFRE.

2.4 Mangrove Conservation Programme

Mangrove forests cover an area of 6 000 km^2, with 59 plant species under 41 genera and 29 families. Taking into consideration the ecological and economic significance of mangroves, the MoEF had launched a Scheme on Conservation and Management of Mangroves and Coral Reefs in 1986 for Conservation and protection of the mangrove ecosystem from further degradation; afforestation of degraded mangrove areas; maintenance of genetic diversity especially of the threatened and endemic species and creation of awareness among the people on importance of mangrove ecosystem and the need for its conservation. Under this programme 35 mangrove areas have been identified for intensive conservation and management. Financial support is given under Management Action Plans for raising mangrove plantations, protection, catchment area treatment, siltation control, pollution abatement, biodiversity conservation, sustainable resource utilization and creating awareness. A National Mangrove Genetic Resource Centre has been established in Odisha, in the east coast of India, for conservation, afforestation and regeneration of mangrove species.

2.5 Medicinal Plants Conservation Programme

India has probably the oldest, richest and most diverse cultural traditions in the use of medicinal plants. NMPB was established for co-ordination and implementation of policies relating to conservation, harvesting, cultivation, research and marketing of medicinal plants through 32 State Medicinal Plant Boards. At the national level 32 medicinal plant species have been selected for research and development. A network of 54 Medicinal Plant Conservation Areas (MPCAs) - "as forest gene bank sites" have been established by SFDs of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra (Ravikumar, 2010) in consultation with the Foundation for Revitalization of Local Health Traditions (FRLHT) and with the support of DANIDA, which harbour 45% of recorded populations of flowering and medicinal plants of Peninsular India, including 70% of the red-listed species. To conserve wild germplasm, revitalize the indigenous health care and livelihood security, as a part of the UNDP-Country Cooperation Framework-II project a 'National Programme on Promoting Conservation of Medicinal Plants and Traditional Knowledge for enhancing Health and Livelihood Security' is under implementation in 9 States.

2.6 Constraints to improving in situ conservation programmes

The main constraint is the resistance to expansion of PA network. There is a general feeling that establishment of PAs leads to hardships to local communities mainly because of (a) restriction on access and use of resources inside PAs; and, (b) increase in human-wildlife conflicts. More concerted efforts are required for the expansion of PA network, particularly in areas where its representation is suboptimal. The connectivity of PA network is to be improved through establishment of corridors. Inadequate capacity and resources to undertake the task of economic evaluation of environmental goods and services emanating from the PAs is another constraint.

Ensuring up to date, site specific and scientific management planning of PAs, is a constraint which needs to be addressed through capacity building. Linking the PAs into the larger landscapes and also integrating the livelihood aspirations of local people in PA management is a challenging task. Eco-development programmes and landscape level interventions need to be invigorated (MOEF, 2009).

Another constraint is the absence of linkage between *in situ* conservation and *ex situ* conservation. The bottlenecks in regeneration of the species conserved *in situ* need to be identified for initiation of *ex situ* conservation followed by species recovery and reintroduction.

2.7 Priorities for future in situ conservation actions

There are a large number of actions related to research and capacity building required to augment the *in situ* conservation efforts. Along with the conservation of ecosystem and biodiversity, the FGR

also get conserved *in situ*, and this is preferred over *ex situ* conservation as the species is conserved in its original habitat, the diversity is maintained and the opportunities for the evolutionary processes to continue are there. The high cost and technology involved in *ex situ* conservation is also a factor not in favour of that, when options for *in situ* conservation are available. The following are the priorities required for *in situ* conservation:

- Species prioritization at country and regional level.
- Species recovery research.
- Creation of exclusive website for FGR with information on different resources.
- Development and maintenance of comprehensive database of FGR.
- Maintenance of a database of taxonomists in the country for inventorisation and documentation of FGR.
- Capacity building for frontline officials, researchers, forest field staff, forest dwelling communities / adjoining rural communities.
- Documentation of traditional knowledge related to FGR
- Documentation and assessment of status of globally threatened taxa in different parts of the country.
- Study on genetic, ecological and population dynamics of different species.
- Studies on pest and diseases affecting the FGR
- Location of earlier established PPP and establishment of new ones and monitoring.
- Creation of certain endemic species protected areas.

The recent decision of the MoEF, Government of India to establish an ENVIS Centre on FGR at the IFGTB will attend to the needs of the maintenance of database on FGR, creation of website on FGR and documentation. The implementation of the Seed zoning concept as evolved in the IDPSTI for all the species of economic interest will help in population genetic studies on many species and establishment of zone-specific seed production populations. The details of the scheme for certification of forest reproductive material and the concept of seed zoning are discussed elsewhere in the report.

2.8 Circa situ conservation

Several of the FGR are conserved in farmlands or in home gardens (*circa situ*). Many of the indigenous species are part of the homestead gardens or are domesticated and planted by the farmers. There are also species that are exotic and localized and many of the land races of exotics are preserved in farmlands through cultivation. Following is the list of such species:

1. *Acacia auriculiformis*
2. *Acacia catechu*
3. *Acacia mangium*
4. *Acacia nilotica*
5. *Acacia senegal*
6. *Adenanthera pavonina*
7. *Aegle marmelos*
8. *Ailanthus excelsa*
9. *Ailanthus triphysa*
10. *Albizia amara*
11. *Albizia chinensis*
12. *Albizia lebbeck*

13. *Albizia odoratissima*
14. *Albizia procera*
15. *Alstonia scholaris*
16. *Anacardium occidentale*
17. *Annona muricata*
18. *Annona reticulata*
19. *Annona sqamosa*
20. *Anogeissus latifolia*
21. *Neolamarckia chinensis*
22. *Aporusa lindleyana*
23. *Araucaria heterophylla*
24. *Areca catechu*
25. *Artocarpus communis*
26. *Artocarpus gomezianus*
27. *Artocarpus heterophyllus*
28. *Artocarpus hirsutus*
29. *Artocarpus ranchi*
30. *Averrhoa bilimbi*
31. *Averrhoa carambola*
32. *Azadirachta indica*
33. *Bambusa bambos*
34. *Bambusa nutans*
35. *Bambusa tulda*
36. *Bambusa vulgaris*
37. *Bauhinia acuminata*
38. *Bauhinia malabarica*
39. *Bauhinia purpurea*
40. *Bauhinia tomentosa*
41. *Bauhinia variegata*
42. *Bombax ceiba*
43. *Bombax insigne*
44. *Borassus flabellifer*
45. *Bridelia retusa*
46. *Butea monosperma*
47. *Caesalpinia coriaria*
48. *Caesalpinia pulcherrima*
49. *Caesalpinia sappan*
50. *Callistemon citrinus*
51. *Calophyllum austro-indicum*
52. *Calophyllum inophyllum*
53. *Cananga odorata*
54. *Carallia brachiata*
55. *Careya arborea*
56. *Carica papaya*
57. *Caryota urens*
58. *Cassia fistula*
59. *Cassia roxburghii*
60. *Casuarina equisetifolia*
61. *Ceiba pentandra*
62. *Celtis australis*
63. *Cerbera odollam*
64. *Chrysophyllum cainito*
65. *Chukrasia tabularis*
66. *Cinnamomum malabatrum*
67. *Cinnamomum zeylanicum*
68. *Citrus maxima*
69. *Citrus medica*
70. *Cleistanthus collinus*
71. *Coffea* spp
72. *Commiphora caudata*
73. *Corypha umbraculifera*
74. *Crateva magna*
75. *Cullenia exarillata*
76. *Cycas circinnalis*
77. *Dalbergia lanceolaria*
78. *Dalbergia latifolia*
79. *Dalbergia sissoides*
80. *Dalbergia sissoo*
81. *Delonix regia*
82. *Dillenia pentagyna*
83. *Diospyros buxifolia*
84. *Diospyros ebenum*
85. *Dipterocarpus bourdillonii*
86. *Dipterocarpus indicus*
87. *Elaeocarpus serratus*
88. *Elaeocarpus tectorius*
89. *Erythrina indica*
90. *Eucalyptus tereticornis*
91. *Eucalyptus camaldulensis*
92. *Eucalyptus globulus*
93. *Eucalyptus grandis*
94. *Eugenia malaccensis*
95. *Evodia lunu-ankenda*
96. *Excoecaria agallocha*
97. *Ficus benghalensis*
98. *Ficus callosa*
99. *Ficus carica*
100. *Ficus elastica*
101. *Ficus exasperata*
102. *Ficus hispida*
103. *Ficus racemosa*
104. *Ficus religiosa*
105. *Ficus tinctoria* var. *parasitica*
106. *Flacourtia inermis*
107. *Flacourtia jangomas*
108. *Flacourtia montana*
109. *Garcinia cambogia*
110. *Garcinia gummi-gutta*
111. *Garcinia mangostana*
112. *Garcinia morella*
113. *Garuga pinnata*
114. *Gliricidia sepium*
115. *Gmelina arborea*
116. *Grevillea robusta*
117. *Grewia glabra*
118. *Grewia optiva*
119. *Grewia tiliifolia*
120. *Haldina cordifolia*
121. *Hardwickia binata*
122. *Hevea brasiliensis*
123. *Holarrhena pubescens*
124. *Holigarna arnottiana*
125. *Holoptelea integrifolia*
126. *Hopea parviflora*
127. *Hydnocarpus alpina*
128. *Hydnocarpus pentandra*
129. *Knema attenuata*
130. *Lagerstroemia microcarpa*
131. *Lagerstroemia parviflora*
132. *Lagerstroemia reginae*
133. *Lannea coromandelica*
134. *Leucaena leucocephala*
135. *Macaranga peltata*
136. *Madhuca longifolia* var. *latifolia*
137. *Mallotus philippensis*
138. *Mangifera indica*
139. *Manihot glaziovii*
140. *Manilkara zapota*
141. *Melia azedarach*
142. *Melia dubia*
143. *Melicope lunu-ankenda*
144. *Memecylon molestum*
145. *Michelia champaca*
146. *Miliusa tomentosa*
147. *Mimusops elengi*
148. *Morinda pubescens*
149. *Moringa oleifera*
150. *Morus alba*
151. *Muntingia calabura*
152. *Murraya koenigii*
153. *Murraya paniculata*
154. *Myristica fragrans*
155. *Nephelium lappaceum*

156. *Olea dioica*
157. *Oroxylum indicum*
158. *Pajanelia rheedi*
159. *Pandanus tectorius*
160. *Paraserianthes falcataria*
161. *Pavetta indica*
162. *Peltophorum pterocarpum*
163. *Persea americana*
164. *Persea macrantha*
165. *Phyllanthus acidus*
166. *Phyllanthus emblica*
167. *Pimenta dioica*
168. *Pithecellobium dulce*
169. *Plumeria rubra*
170. *Polyalthia longifolia*
171. *Polyscias acuminata*
172. *Pongamia pinnata*
173. *Pouteria campechiana*
174. *Prosopis cineraria*
175. *Psidium guajava*
176. *Pterocarpus marsupium*
177. *Pterocarpus santalinus*
178. *Samadera indica*
179. *Santalum album*
180. *Sapindus laurifolia*
181. *Sapindus trifoliatus*
182. *Saraca asoca*
183. *Schleichera oleosa*
184. *Semecarpus anacardium*
185. *Sesbania grandiflora*
186. *Spondias indica*
187. *Spondias mangifera*
188. *Sterculia foetida*
189. *Sterculia guttata*
190. *Stereospermum chelonoides*
191. *Stereospermum colais*
192. *Streblus asper*
193. *Strychnos nux-vomica*
194. *Sweitenia mahagoni*
195. *Swieteinia macrophylla*
196. *Syzygium aqueum*
197. *Syzygium aromaticum*
198. *Syzygium cumini*
199. *Syzygium jambos*
200. *Syzygium laetum*
201. *Syzygium malaccense*
202. *Tabernaemontana heyneana*
203. *Taliparitiliaceum*
204. *Tamarindus indica*
205. *Tecoma stans*
206. *Tecomella undulata*
207. *Tectona grandis*
208. *Terminala catappa*
209. *Terminalia bellirica*
210. *Terminalia chebula*
211. *Terminalia elliptica*
212. *Terminalia paniculata*
213. *Theobroma cacao*
214. *Thespesia populnea*
215. *Toona ciliata*
216. *Trema orientalis*
217. *Trewia polycarpa*
218. *Vateria indica*
219. *Vateria macrocarpa*
220. *Vatica chinensis*
221. *Vitex altissima*
222. *Wrightia arborea*
223. *Wrightia tinctoria*
224. *Xanthophyllum arnottianum*
225. *Xylia xylocarpa*
226. *Zanthoxylum rhetsa*

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CHAPTER 3

THE STATE OF *EX SITU* GENETIC CONSERVATION

The conservation of genetic material or elements of biodiversity out of the context of their natural habitats is referred to as *ex-situ* conservation. It is the process of protecting an endangered species of plant or animal by removing part of the population from a threatened habitat and placing it in a new location, which may be a wild area or within the care of humans. While *ex-situ* conservation comprises some of the oldest and best known conservation methods, it also involves newer, sometimes laboratory methods. Generally, the conservation takes place in facilities which support either storage or the continuity of the conditions suited to maintain the viability and genetic constitution of the genetic material or diversity.

Ex situ conservation virtually safeguards and provides a required supply of germplasm for research and breeding. It has several purposes:

- Produce material for conservation biology research.
- Bulk up germplasm for storage in various forms of *ex situ* facility.
- Rescue threatened germplasm.
- Supply material for various purposes to remove or reduce pressure from wild collecting.
- Grow those species with recalcitrant seeds that cannot be maintained in a seed store.
- Make available material for conservation education and display.
- Produce material for reintroduction, reinforcement, habitat restoration and management.

The various possible approaches in *ex situ* conservation of FGR are:

- Provenance trials comparing trees grown from seed or cuttings collected in many parts of a species range
- Seed orchards - plantations established for the production of tree seed.
- Clonal repositories that are collection of clones of a species
- Botanical gardens - where plants, especially ferns, conifers and flowering plants, are grown and displayed for the purposes of research and education
- Arboreta - where trees are grown and displayed for the purposes of research and education
- Herbal gardens - where plants of known medicinal values are grown and displayed for the purposes of research and education
- Seed and pollen banks - storing seeds as a source for planting in case seed reserves elsewhere are destroyed and pollen for controlled pollination. It facilitates germplasm exchange.
- Vegetative propagules - stored under controlled conditions

- Tissue and cell cultures- stored under controlled conditions

3.1 Target tree species included in ex-situ conservation programmes

Based on the priority species listed by APFORGEN, FAO, FGRMN and ICFRE, 153 species and a number of bamboos are shortlisted for *ex-situ* conservation measures with a focus on tree improvement and productivity and other conservation methods. The list of species is at Table 11.

The *ex situ* conservation efforts in the country can be broadly categorized into two groups, namely the efforts by the botanists in conserving the species in the botanical gardens for their biological value and the other by the tree breeders attempting to improve the productivity of the species.

India has more than 100 botanical gardens under different management systems located in different bio-geographical regions. The Botanical Garden of Indian Republic (BGIR) has been established in April 2002 as part of BSI by MoEF. Its main objective is *ex-situ* conservation and propagation of rare and indigenous plants. Assistance to Botanic Gardens and Centres has been given by MoEF since 1992 to augment *ex-situ* conservation of rare endemic plants. Under the scheme, financial assistance is provided to the botanical gardens for improvement of their infrastructural facility. The scheme helps in strengthening *ex-situ* conservation of rare endemic plants and providing education through network of existing Botanical Gardens. Three Gene Banks have been set up to conserve genetic resources including medicinal plants by G. B. Pant Institute of Himalayan Environment and Development. *Ex-situ* conservation of medicinal plants in degraded forest areas is undertaken under the Joint Forest Management (JFM) programme. Karnataka, Kerala and Tamil Nadu have developed Medicinal Plants Development Area (MPDA) under the project funded by DANIDA and executed jointly by Foundation for Revitalization of Local Health Traditions (FRLHT) and the State Forest Departments.

There are ongoing long-term breeding programmes for *Acacia auriculiformis, A. mangium, Casuarina equisetifolia, C. junghuhniana, Dalbergia sissoo, Eucalyptus camaldulensis, E. tereticornis*, *Tectona grandis* and Poplars in the country. All these programmes include provenance-progeny tests which are raised by open-pollinated family seedlots. The provenance trials help in exploitation of gene resources through genecological exploration, patterns of ecological and phenotypic variation within the natural range of species. Provenance trials of more than 90 species have been laid out in different parts of India to screen out the best provenances for raising new plantations with increased productivity. The first provenance trials were for two important native species, *Tectona grandis* and *Pinus roxburghii*, initiated by Prof. M.L. Laurie and Sir Harry G. Champion, respectively. International provenance trials of Teak and *Gmelina arborea* have been established in different states in collaboration with the DANIDA Forest Seed Centre (DFSC).

There are seed orchards established primarily for the production of seed of proven genetic quality. These orchards can be put under selective conservation, as one of the objectives in *ex-situ* conservation. Establishment of seed orchards is part of long-term conservation management programme and also a long-term breeding programme.

Germplasm banks and clone banks have also been established for many forest species. The germplasm in these banks are characterized for morphological characters for the purpose of identification and registration of clones and biochemical and physiological characters for the purpose of selection and breeding. They are also observed for growth characters at yearly intervals.

Defence Institute of High Altitude Research (DIHAR), the only lab in the world located at 3500 m above mean sea level at Leh (Ladakh) has core competence in cold arid agro-animal technologies. It has created a National Perma Frost Based Germplasm Storage Faciltiy at an altitude of 5360 m above mean sea level (75 km from Leh). This will serve as a germplasm storage facility and safety net for current and future food security in the era of global warming and climate change. This structure is for the successful, cost-effective, safe and long term conservation of valuable plant genetic resources for food and agriculture (PGRFA) in the form of safety duplicates. The structure is designed on 'black box condition' storage mechanism by which the storage boxes remain the property of the institution which send them and could be opened only with title depositor's permission, avoiding conflicts pertaining to intellectual property rights. The same can also be used for *ex situ* conservation of FGR.

Table 11.

Ex situ conservation

S. No.	Species		Field collections				Germplasm bank			
	Scientific name	Native (N) or Exotic (E)	Collections, provenances or progeny tests, arboreta or conservation stands		Clone banks		In vitro (include Cryoconser-vation)		Seed banks	
			No. stands	No. acc	No. banks	No. clone	No. banks	No. acc	No. banks	No. acc
1.	*Abies pindrow*	N	3	√	--	--	--	--	--	--
2.	*Acacia albida*	E	1	√	--	--	--	--	--	--
3.	*Acacia aulacocarpa*	E	1	√	--	--	--	--	--	--
4.	*Acacia auriculiformis*	E	4	3 122	√	--	√	√	√	--
5.	*Acacia catechu*	N	9	179	--	--	--	--	--	--
6.	*Acacia crassicarpa*	E	1	√	--	--	--	--	--	--
7.	*Acacia leucophloea*	N	1	3	--	--	--	--	--	--
8.	*Acacia lucida*	N	1	1						
9.	*Acacia mangium*	E	13	197	√	√	--	--	√	--
10.	*Acacia mearnsii*	E	3	248	--	--	--	--	--	--
11.	*Acacia nilotica*	N	121	719	--	1	√	--	--	--
12.	*Acacia occidentalis*	N	1	12	--	--	--	--	--	--
13.	*Acacia senegal*	E	2	√	--	--	--	--	--	--
14.	*Acacia tortilis*	N	2	√	--	--	--	--	--	--
15.	*Acrocarpus fraxinifolius*	N	1	7	--	--	--	--	--	--
16.	*Aegle marmelos*	N	2	10	--	--	1	80	--	--
17.	*Ailanthus excelsa*	N	6	√	--	--	--	--	--	--
18.	*Ailanthus triphysa*	N	5	√	--	--	√	--	--	--
19.	*Albizia arunachalensis*	N	1	1	--	--	--	--	--	--

20.	*Albizia lebbeck*	N	13	√	--	30	--	--	--	25
21.	*Albizia odoratissima*	N	1	√	--	--	--	--	--	--
22.	*Albizia procera*	N	3	51	--	--	--	--	--	--
23.	*Albizia richardiana*	N	1	√	--	--	--	--	--	--
24.	*Alstonia scholaris*	N	1	√	--	--	--	--	--	--
25.	*Altingia excelsa*	N	1	1	--	--	--	--	--	--
26.	*Amoora wallichii*	N	1	1	--	--	--	--	--	--
27.	*Anogeissus latifolia*	N	5	√	--	--	--	--	--	--
28.	*Antidesma acuminatum*	N	1	1	--	--	--	--	--	--
29.	*Aquilaria malaccensis*	N	1	1	--	--	--	--	--	--
30.	*Artocarpus heterophyllus*	N	6	√	--	72	--	--	--	--
31.	*Azadirachta indica*	N	45	677	--	15	--	--	√	40
32.	*Bamboos*	N	18	754	√	√	--	--	--	--
33.	*Bauhinia purpurea*	N	1	3	--	--	--	1	--	--
34.	*Bauhinia racemosa*	N	2	√	--	--	--	--	--	--
35.	*Bauhinia variegata*	N	1	26	--	--	--	--	--	--
36.	*Bombax cieba*	N	9	96	--	--	--	--	--	--
37.	*Boswellia serrata*	N	1	√	--	--	--	--	--	--
38.	*Buchanania lanzan*	N	3	11	--	--	1	127	--	--
39.	*Butea monosperma*	N	-	-	--	15	--	--	-	15
40.	*Calophyllum inophyllum*	N	1	√	--	--	--	--	√	--
41.	*Capparis decidua*	N	1	√	--	--	1	88	-	--
42.	*Cassia fistula*	N	2	√	--	--	--	--	--	--
43.	*Cassia siamea*	N	3	√	--	--	--	--	--	--
44.	*Casuarina equisetifolia*	E	40	√	√	√	--	--	√	√
45.	*Casuarina junghuhniana*	E	5	√	√	√	--	--	√	--
46.	*Cedrus deodara*	N	4	√	--	--	--	--	√	--
47.	*Celtis australis*	N	2	√	--	--	--	--	--	--
48.	*Chloroxylon swietenia*	N	1	√	--	--	--	--	--	--
49.	*Chukrasia tabularis*	N	2	√	1	--	--	--	--	--
50.	*Cinnamomum cecidodaphnae*	N	1	√	--	--	--	--	--	--
51.	*Commiphora wightii*	N	1	√	--	4	--	--	--	--
52.	*Cordia myxa*	N	1	√	--	--	1	24	--	--
53.	*Cupressus torulosa*	N	2	√	--	---	--	--	--	--
54.	*Dalbergia latifolia*	N	4	388	--	--	√	--	--	--
55.	*Dalbergia sissoo*	N	51	663	√	√	--	--	√	--
56.	*Dillenia indica*	N	1	√	--	--	--	--	--	--
57.	*Diospyros melanoxylon*	N	3	√	--	--	1	16	--	--
58.	*Dipterocarpus* spp.	N	4	130	--	--	--	--	--	--
59.	*Duabanga sonneratioides*	N	2	11	--	--	--	--	--	--
60.	*Elaeocarpus aristatus*	N	1	1	--	--	--	--	--	--
61.	*Elaeocarpus rugosus*	N	1	1	--	--	--	--	--	--
62.	*Elaeocarpus sphaericus*	N	1	1	--	--	--	--	--	--
63.	*Eucalyptus* spp.	E	100	1 417	2	44	√	1	√	1
64.	*Evodia glabra*	N	1	√	--	--	--	--	--	--
65.	*Ficus* spp.	N	11	√	--	--	--	--	--	--
66.	*Fraxinus xanthoxyloides*	N	1	√	--	--	--	--	√	--
67.	*Gmelina arborea*	N	45	263	√	√	--	2	--	--
68.	*Grewia optiva*	N	3	√	--	--	--	--	--	--

69.	*Grewia tiliifolia*	N	1	√	--	--	1	1	--	--
70.	*Gyrocarpus asiaticus*	N	1	√	--	--	--	--	--	--
71.	*Haldina cordifolia*	N	6	√	--	--	--	--	--	--
72.	*Hardwickia binata*	N	5	√	--	--	--	--	--	--
73.	*Hevea brasiliensis*	E	--	--	--	4 548	--	--	--	--
74.	*Holoptelea integrifolia*	N	1	√	--	--	--	--	--	--
75.	*Hopea parviflora*	N	1	√	--	√	--	--	--	--
76.	*Horsfeldia amygdalina*	N	1	1	--	--	--	--	--	--
77.	*Jatropha curcas*	E	26	√	--	128	--	145	--	25
78.	*Juglans regia*	N	5	√	--	--	--	--	--	--
79.	*Knema linifolia*	N	1	1	--	--	--	--	--	--
80.	*Kydia glabrescens*	N	1	1	--	--	--	--	--	--
81.	*Leucaena leucocephala*	E	5	496	3	12	--	--	√	--
82.	*Limonia acidissima*	N	3	48	--	--	--	--	--	--
83.	*Livistona jenkinsiana*	N	1	1	--	--	--	--	--	--
84.	*Madhuca indica*	N	1	√	--	5	1	2	--	20
85.	*Madhuca longifolia*	N	1	√	--	--	1	12	--	--
86.	*Mangifera indica*	N	1	√	--	--	--	--	--	--
87.	*Manilkara hexandra*	N	1	√	--	--	1	14	--	--
88.	*Melia azedarach*	N	3	√	--	--	--	--	--	--
89.	*Melia dubia*	N	√	√	--	--	--	--	--	--
90.	*Mesua ferrea*	N	1	7	--	--	--	--	--	--
91.	*Michelia champaca*	N	2	√	--	--	--	--	--	--
92.	*Michelia montana*	N	1	1	--	--	--	--	--	--
93.	*Mimusops elangi*	N	1	√	--	--	--	--	--	--
94.	*Mitragyna parvifolia*	N	1	√	--	--	--	--	--	--
95.	*Morinda tinctoria*	N	1	√	--	--	--	--	--	--
96.	*Morus alba*	E	3	41	1	--	1	46	--	--
97.	*Morus laevigata*	E	3	118	1	--	1	30	--	--
98.	*Myristica* spp.	N	1	√	--	--	--	--	--	--
99.	*Neolamarckia cadamba*	N	1	8	--	--	--	--	--	--
100.	*Oroxylum indicum*	N	3	√	--	--	--	--	--	--
101.	*Parkia roxburghii*	N	1	1	--	--	--	--	--	--
102.	*Phoebe goalparensis*	N	1	1	--	--	--	--	--	--
103.	*Phyllanthus emblica*	N	12	31	--	53	1	31	√	--
104.	*Picea smithiana*	N	2	√	--	--	--	--	--	--
105.	*Pinus gerardiana*	N	1	√	--	--	--	--	√	--
106.	*Pinus kesiya*	E	1	√	--	--	--	--	--	--
107.	*Pinus patula*	E	2	√	--	--	--	--	--	--
108.	*Pinus roxburghii*	N	23	63	--	--	--	--	√	--
109.	*Pinus wallichiana*	N	4	√	--	--	--	--	√	--
110.	*Pithecellobium dulce*	E	4	√	--	--	1	14	√	--
111.	*Podocarpus nerifolius*	E	1	√	--	--	--	--	--	--
112.	*Pongamia pinnata*	N	3	219	--	25	--	--	--	10
113.	*Populus ciliata*	N	8	√	--	--	--	--	--	--
114.	*Populus deltoides*	E	2	√	1	400	--	--	--	--
115.	*Prosopis cineraria*	N	6	√	--	--	--	--	--	453
116.	*Prosopis juliflora*	E	3	358	--	--	--	--	--	--
117.	*Prosopis pallida*	E	1	√	--	--	--	--	--	--
118.	*Pterocarpus dalbergioides*	N	1	9	--	--	--	--	--	--

119.	*Pterocarpus marsupium*	N	9	39	--	2	--	--	--	--
120.	*Pterocarpus santalinus*	N	4	√	--	2	--	--	--	--
121.	*Salix tetrasperma*	N	√	√	√	8	--	--	--	--
122.	*Santalum album*	N	19	√	4	79	--	--	--	--
123.	*Salvadora oleoides*	N	--	--	--	--	1	23	--	--
124.	*Salvadora persica*	N	--	--	--	--	1	12	--	--
125.	*Sapindus emarginatus*	N	1	√	--	--	--	--	--	--
126.	*Sapium eugenifolium*	N	1	1	--	--	--	--	--	--
127.	*Saraca asoca*	N	--	--	--	3	--	--	--	--
128.	*Schima wallichii*	N	1	1	--	--	--	--	--	--
129.	*Schleichera oleosa*	N	1	√	--	1	--	--	--	--
130.	*Shorea assamica*	N	1	1	--	--	--	--	--	--
131.	*Shorea robusta*	N	3	37	--	--	--	--	--	--
132.	*Spondias axillaris*	N	1	1	--	--	--	--	--	--
133.	*Sterculia urens*	N	4	√	--	--	--	--	--	--
134.	*Strychnos nux-vomica*	N	1	√	--	6	--	--	--	--
135.	*Styrax serrulatum*	N	1	1	--	--	--	--	--	--
136.	*Swietenia macrophylla*	N	4	√	--	--	--	--	--	--
137.	*Swietenia mahagoni*	N	4	√	--	--	--	--	--	--
138.	*Syzygium cumini*	N	16	√	--	--	--	--	--	--
139.	*Talauma hodgsonii*	N	1	1	--	--	--	--	--	--
140.	*Tamarindus indica*	N	9	√	1	33	1	10	--	--
141.	*Taxus wallichiana*	N	3	√	--	--	--	--	--	--
142.	*Tectona grandis*	N	36	917	√	--	--	--	√	--
143.	*Terminalia arjuna*	N	5	119	--	4	--	1	--	--
144.	*Terminalia bellerica*	N	4	√	--	--	--	15	--	--
145.	*Terminalia chebula*	N	2	√	--	--	--	29	--	--
146.	*Terminalia cattappa*	N	--	--	--	--	--	2	--	--
147.	*Terminalia myriocarpa*	N	3	14	--	--	--	--	--	--
148.	*Terminalia paniculata*	N	--	--	--	--	--	1	--	--
149.	*Vateria indica*	N	1	√	--	--	--	--	--	--
150.	*Vatica lancifolia*	N	1	1	--	--	--	--	--	--
151.	*Wrightia tinctoria*	N	1	√	--	--	--	--	--	--
152.	*Xylia xylocarpa*	N	4	√	--	--	--	--	--	--
153.	*Zanthoxylum rhetsa*	N	1	1	--	--	--	--	--	--
154.	*Ziziphus mauritiana*	N	2	√	--	--	--	43	--	--

√- indicates that it is available, but the details are not known.

National Medicinal Plants Board (NMPB) has been setup by Ministry of Health and Family Welfare to function as a nodal agency for *ex-situ* conservation of medicinal plants in the country. Thirty two medicinal plants have been identified as priority species for conservation and promotion of cultivation and 344 medicinal plants gardens have been established by various agencies funded by the board.

National Oil Seeds and Vegetable Oil Development Board (NOVOD) has been setup by Ministry of Agriculture for Integrated Development of Tree Borne Oilseeds (TBO) like *Diploknema butyracea, Jatropha curcas, Simmondsia chinesis, Pongamia pinnata, Garcinia indica, Madhuca indica, Azadirachta indica, Simarouba glauca, Aleurites* species and *Prunus armeniaca.* Financial assistance up to 80% is given by the Board for establishment of TBO garden and parks.

NBM set up by the Ministry of Agriculture for promotion of cultivation, utilization and marketing of Bamboo species viz., *Bambusa tulda, Bambusa nutans, Bambusa bambos, Bambusa*

pallida, Bambusa vulgaris, Bambusa balcooa, Dendrocalamus hamiltoni, Dendrocalamus giganteus, Dendrocalamus asper, Dendrocalamus strictus, Melocanna baccifera, Ochlandra travancoria and *Oxytenanthera parviflora*. This mission focuses on research and development activities related to development of varieties and technologies for enhanced production.

3.2. Main constraints to improving ex situ conservation in the country

India is a mega biodiversity country. There are many species which require conservation outside the original habitat. Availability of land outside the original habitat having similar growing conditions is a major constraint for conservation of many species.

The other constraints to sustain *ex situ* collections are lack of funding and limited number of trained staff to cover all activities related with management of FGR following all possible approaches. Lack of adequate facilities or infrastructure development is also a constraint in SFDs and in some organizations.

Efforts for establishment and management of *ex-situ* areas need to be coordinated by a single nodal agency. Many species are handled by more than one organization, maintained in large areas and at the same time a few species are not given attention. Therefore, there is a need for prioritization of the species for *ex situ* conservation which could be based on demand for the species or economic value. *Ex-situ* conservation being a long term effort requires constant institutionalized support.

3.3. Priorities for future ex situ conservation actions

- *Ex-situ* conservation strategies need to be developed with expert vision to cater to the future needs.
- As there are many priority species, the efforts need to be taken up by many agencies coordinated by a nodal agency.
- The efforts must be proportional to the present knowledge on the utility of the species.
- The germplasm must be collected scientifically considering the variability present in different populations covering the core population and other populations in a proportion.
- For better management practices to reduce genetic changes or loss of genetic integrity, attention must be paid to select suitable regeneration environment, adequate population size and proper handling of regenerated material.
- Funds must be set apart for maintenance of the *ex-situ* conservation areas.
- In future collection for *ex situ* conservation stands should aim at capturing maximum genetic diversity through prior knowledge on the extent and pattern of genetic variation within the species. Genetic diversity studies at DNA level and gene-ecological studies are needed for planning the *ex situ* germplasm collection. Capacity building is needed in these areas.

- Proper *ex situ* conservation measures should be adopted for materials procured for research purposes.
- The threatened status of the species is to be considered before embarking on collection from the wild.
- For future conservation strategies, a national strategy for conservation and management of FGR similar to national strategies on wildlife, biodiversity, etc., to be formulated.
- There is a need for maintaining registers at national level for species deployed for tree improvement and sharing of FGR.

3.4. Other relevant information on ex situ conservation

Ex situ conservation efforts will be meaningful only through involvement of local communities. As conservation efforts are long term programmes, they do not result in immediate benefits to the local communities, and naturally the response from them will be poor. Strategies need to be worked out to involve the local communities in such efforts.

Unlike the temperate countries, India being the tropical country, it hosts many forest types and is one of the mega biodiversity centres. The innumerable number of species poses great challenge in *ex-situ* conservation efforts. Many of the evergreen species seeds are recalcitrant in nature and not amenable for traditional storage methods. The tropical forests have various types of seeds like orthodox seeds, recalcitrant seeds, intermediate seeds, temperature sensitive seeds and many more types of seeds, the science of which is not yet understood. These issues need to be addressed with proper funding support.

The policy makers have to be apprised about the need for *ex situ* conservation. There should be national policy and strategies for *ex situ* conservation efforts involving the forest departments, research organizations, universities and local communities.

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CHAPTER 4

THE STATE OF USE AND SUSTAINABLE MANAGEMENT OF FOREST GENETIC RESOURCES

4.1 Genetic improvement programmes and their implementation

There are a large number of species that are presently under various stages of domestication in India. With a view to improve the productivity CPT selection has been carried out in many species and progeny trials established. SPAs, CSOs, SSOs, VMGs and modern nurseries have been established for the production of quality planting material. The importance of production forestry has been realized and strategic activities for tree improvement are in progress in the ICFRE institutes, SFDs and agricultural universities. ICFRE has developed comprehensive strategies for tree improvement of species like teak, neem, acacias, pines, eucalypts, bamboos, poplars, *Dalbergia* spp., *Casuarina* spp., *Cedrus deodara*, *Jatropha* spp., *Albizia* spp. and *Gmelina* spp. The following ICFRE institutes have assembled germplasm of various species: Forest Research Institute (FRI), Dehradun, Tropical Forest Research Institute (TFRI), Jabalpur, Arid Forest Research Institute (AFRI), Jodhpur, Rain Forest Research Institute (RFRI), Jorhat and IFGTB, Coimbatore.

In addition, international provenances of neem, *Gmelina,* teak, pines, *Casuarina* spp., eucalypts and acacias have been assembled. Provenance trials at a national level for various species like *Dalbergia sissoo*, pines and acacias have also been conducted. Improved seeds from clonal seed orchards and seedling seed orchards of some species are made available for planting to user agencies.

For the process of tree improvement of many of the exotic species, seeds have been transferred internationally under various programmes like FORTIP. The details of seeds transferred internationally are provided at Table 12.

Table 12

Seed and vegetative propagules transferred internationally per annum (Average of last 5 years)

Species		Quantity of seed (Kg)		Number of vegetative Propagules		Number of seedlings		Purpose
Scientific name	Native (N) or Exotic (E)	Import	Export	Import	Export	Import	Export	
1. *Casuarina junghuhniana*	Exotic	0.100	--	--	--	--	--	Research
2. *Eucalyptus brassiana*	Exotic	0.050	--	--	--	--	--	Research
3. *Eucalyptus camaldulensis*	Exotic	9.620	--	--	--	--	--	Research/ Planting
4. *Eucalyptus gomphocephala*	Exotic	0.043	--	--	--	--	--	Research
5. *Eucalyptus grandis*	Exotic	0.020	--	--	--	--	--	Research
6. *Eucalyptus occidentalis*	Exotic	0.020	--	--	--	--	--	Research
7. *Eucalyptus pellita*	Exotic	0.050	--	--	--	--	--	Research
8. *Eucalyptus smithii*	Exotic	0.010	--	--	--	--	--	Research
9. *Eucalyptus tereticornis*	Exotic	0.025	--	--	--	--	--	Research
10. *Eucalyptus urophylla*	Exotic	0.120	--	--	--	--	--	Research
11. *Pinus carribaea*	Exotic	25.00	--	--	--	--	--	Research

The tree improvement programmes undertaken in India have largely concentrated on increase in volume of timber, as that is the prime requirement, in a state of timber deficit. The primary breeding objective still remains the volume increase in most of the breeding programmes. Wherever, the breeding programme has advanced beyond the first generation, other breeding objectives to improve the pulping or wood quality, pest tolerance, disease resistance, etc., are also being attended to. The list of important tree improvement programmes carried out in the country is at Table 13.

Table 13.

Forest tree improvement programmes.

Species			Improvement programme objective				
Scientific name	Native (N)/exotic (E)	Timber	Pulp wood	Energy	MP*	NW FP**	Other/ ply wood / Latex
1. *Abies pindrow*	N	√	-	-	-	-	-
2. *Acacia auriculiformis*	E	√	√	√	-	-	-
3. *Acacia catechu*	E	√	√	√	-	-	-
4. *Acacia hybrid*	N	-	√	-	√		
5. *Acacia leucophloea*	E	-	√	-	√		
6. *Acacia mangium*	E	√	√	√	-	-	-
7. *Acacia nilotica*	E	√	√	√	-	-	-
8. *Acacia senegal*	N	-	-	-	-	√	-
9. *Acrocarpus fraxinifolius*	N	√	-	-	-	-	-
10. *Aegle marmelos*	N	-	-	-	-	-	√
11. *Ailanthus excelsa*	N	-	√	√	-	-	√
12. *Ailanthus grandis*	N	√	-	-	-	-	-
13. *Ailanthus triphysa*	N	-	√	√	-	-	√
14. *Albizia lebbeck*	N	√	-	-	-	-	-
15. *Albizia odoratissima*	N	√	-	-	-	-	-
16. *Albizia procera*	N	√	-	-	-	-	-
17. *Alstonia scholaris*	N	√	-	-	-	-	-
18. *Altingia excelsa*	N	√	-	-	-	-	-
19. *Amoora wallichii*	N	√	-	-	-	-	-
20. *Anogeissus latifolia*	N	√	-	-	-	√	-
21. *Aquilaria malaccensis*	N	-	-	-	-	√	-
22. *Artocarpus heterophyllus*	N	√	-	-	√	√	-
23. *Azadirachta indica*	N	√	-	√	√	-	-
24. *Bambusa balcooa*	N	-	√	-	-	-	-
25. *Bambusa nutans*	N	-	√	-	-	-	-
26. *Bambusa pallida*	N	-	√	-	-	-	-
27. *Bambusa tulda*	N	-	√	-	-	-	-
28. *Bambusa vulgaris*	N	-	√	-	-	-	-
29. *Bauhinia racemosa*	N	-	-	-	-	-	√
30. *Bauhininia variegata*	N	-	-	-	-	-	√
31. *Bombax ceiba*	N	√	√	-	-	-	-
32. *Boswellia serrata*	N	-	-	-	-	√	-
33. *Buchanania lanzan*	N	√	-	-	√	√	-
34. *Calophyllum inophyllum*	N	-	-	√	√	√	-

35.	*Canarium resiniferum*	N	-	-	-	-	-	√
36.	*Canarium strictum*	N	-	-	-	-	-	√
37.	*Capparis decidua*	N	√	-	-	-	-	-
38.	*Cassia fistula*	N	-	-	-	-	-	√
39.	*Casuarina junghuhniana*	E	-	√	-	-	-	-
40.	*Casurina equisetifolia*	E	-	√	-	-	-	-
41.	*Cedrus deodara*	N	-	-	-	-	√	-
42.	*Chloroxylon swietenia*	N	√	-	-	-	-	-
43.	*Chukrasia tabularis*	N	√	-	-	-	-	-
44.	*Cinnamomum cecidodaphne*	N	-	-	-	-	-	√
45.	*Commiphora wightii*	N	-	-	-	-	-	√
46.	*Cupressus torulosa*	N	-	-	-	-	-	√
47.	*Dalbergia latifolia*	N	√	-	-	-	-	-
48.	*Dalbergia sissoo*	N	√	-	-	-	-	-
49.	*Dendrocalamus hamiltonii*	N	-	√	-	-	-	-
50.	*Dendrocalamus strictus*	N	-	-	-	√	-	-
51.	*Dillenia indica*	N	-	-	-	√	-	-
52.	*Diospyros melanoxylon*	N	-	-	-	-	√	-
53.	*Dipterocarpus macrocarpus*	N	√	-	-	-	-	-
54.	*Dipterocarpus retusus*	N	√	-	-	-	-	-
55.	*Duabanga grandiflora*	N	√	-	-	-	-	-
56.	*Duabanga sonneratioides*	N	√	-	-	-	-	-
57.	*Endospermum chinensis*	N	√	-	-	-	-	-
58.	*Eucalyptus camaldulensis*	E	√	√	√	√	-	-
59.	*Eucalyptus grandis*	E	√	√	√	√	-	-
60.	*Eucalyptus occidentalis*	E	√	√	√	√	-	-
61.	*Eucalyptus pellita*	E	√	√	√	√	-	-
62.	*Eucalyptus tereticornis*	E	√	√	√	√	-	-
63.	*Eucalyptus urophylla*	E	√	√	√	√	-	-
64.	*Evodia lunu-ankenda*	N	-	-	-	-	-	√
65.	*Ficus* spp.	N	-	-	-	√	-	-
66.	*Fraxinus xanthoxyloides*	N	√	-	-	-	√	-
67.	*Garcinia indica*	N	-	-	-	-	-	√
68.	*Garuga pinnata*	N	-	-	-	-	-	√

69.	*Gmelina arborea*	N	√	√	-	-	-	-
70.	*Grewia tiliifolia*	N	√	-	-	-	-	-
71.	*Gyrocarpus americanus*	N	√	-	-	-	-	-
72.	*Haldina cordifolia*	N	√	-	-	-	-	-
73.	*Hardwickia binata*	N	√	-	-	-	-	-
74.	*Hevea brasiliensis*	E	√	-	-	-	-	√
75.	*Holoptelea integrifolia*	N	√	-	-	-	-	√
76.	*Hopea parviflora*	N	√	-	-	-	-	√
77.	*Illicium griffithii*	N	√	-	-	-	√	-
78.	*Jatropha curcas*	E	√	-	-	-	√	-
79.	*Juglans regia*	N	√	-	-	-	-	√
80.	*Lannea coromendalica*	N	-	-	-	-	√	-
81.	*Leucaena leucocephala*	E	-	√	-	-	-	-
82.	*Limonia acidissimia*	N	-	-	-	-	√	√
83.	*Madhuca longifolia*	N	-	-	-	-	√	√
84.	*Mangifera indica*	N	-	-	-	√	-	-
85.	*Melia azedarach*	E	√	-	-	-	-	-
86.	*Melia dubia*	N	√	√	√	√	-	√
87.	*Mesua ferrea*	N	√	-	-	-	√	-
88.	*Michelia champaca*	N	√	-	-	-	-	-
89.	*Mimusops elengi*	N	√	-	-	-	-	-
90.	*Mitragyna parvifolia*	N	√	-	-	-	-	-
91.	*Morinda tinctoria*	N	-	-	-	-	-	√
92.	*Morus alba*	N	-	-	-	-	-	√
93.	*Morus laevigata*	N	-	-	-	-	-	√
94.	*Myristica* spp.	N	-	-	-	-	-	√
95.	*Neolamarckia cadamba*	N	√	√	-	-	√	-
96.	*Oroxylum indicum*	N	-	-	-	√	-	-
97.	*Ougeinia oojenensis*	N	√	-	-	-	-	√
98.	*Phoebe cooperiana*	N	√	-	-	-	-	√
99.	*Phoebe goalparensis*	N	√	-	-	-	-	√
100.	*Phyllanthus emblica*	N	-	-	-	-	√	√
101.	*Picea smithiana*	N	√	-	-	-	-	-
102.	*Pinus carribaea*	E	√	√	-	√	-	-
103.	*Pinus gerardiana*	N	-	-	-	-	√	-
104.	*Pinus kesiya*	E	-	-	-	-	√	-
105.	*Pinus patula*	N	√	-	-	-	-	-
106.	*Pinus roxburghii*	E	-	-	-	-	√	-
107.	*Pinus wallichiana*	E	-	-	-	-	√	-
108.	*Podocarpus nerifolius*	N	-	-	-	-	√	-
109.	*Pongamia pinnata*	N	-	-	-	-	√	-

110. *Populus ciliata*	E	√	√	-	-	-	-
111. *Populus deltoides*	E	√	√	-	-	-	√
112. *Prosopis cineraria*	N	√	-	-	-	-	-
113. *Prosopis juliflora*	E						
114. *Prunus armeniaca*	E						
115. *Pterocarpus dalbergoides*	N	√	-	-	-	-	-
116. *Pterocarpus marsupium*	N						
117. *Pterocarpus santalinus*	N	√	-	-	-	-	√
118. *Rhododendron arboreum*	N						
119. *Salix alba*	N	√	-	-	-	-	-
120. *Santalum album*	N	√	-	-	-	√	-
121. *Sapindus emarginatus*	N	-	-	-	-	√	-
122. *Schleichera oleosa*	N						
123. *Shorea assamica*	N	√	-	-	-	-	-
124. *Shorea robusta*	N	√	-	-	-	-	-
125. *Simarouba glauca*	E	-	-	-	-	√	√
126. *Sterculia urens*	N	-	-	-	-	√	-
127. *Strychnos nux-vomica*	N	√	-	-	-	√	-
128. *Swietenia macrophylla*	N	√	-	-	-	-	-
129. *Swietenia mahogani*	E	√	-	-	-	-	-
130. *Syzygium cumini*	N	√	-	-	-	√	√
131. *Tamarindus indica*	E	-	-	-	-	√	-
132. *Taxus wallichiana*	N	√	-	-	-	-	-
133. *Tecomella undulata*	N	√	-	-	√	√	-
134. *Tectona grandis*	N	√	-	-	-	-	-
135. *Terminalia arjuna*	N	√	-	-	√	√	-
136. *Terminalia bellirica*	N	√	-	-	√	√	-
137. *Terminalia chebula*	N	-	-	-	-	√	-
138. *Terminalia manii*	N	√	-	-	-	-	-
139. *Terminalia myriocarpa*	N	-	-	-	-	√	-
140. *Tetrameles nudiflora*	N	√	-	-	-	v	-
141. *Thespesia populnea*	N	√	-	-	-	-	-
142. *Vateria indica*	N	√	-	-	-	-	-
143. *Wrightia tinctoria*	N	√	-	-	-	-	-
144. *Xylia xylocarpa*	N	√	-	-	-	-	-
145. *Ziziphus jujuba*	N	√	-	-	-	√	-

* MP: Multipurpose tree improvement programme **NWFP: Non-wood forest product

For the trees listed in Table 13, a large number of plus trees have been selected. Provenance and progeny trials have been laid out. In many cases the progeny trials, on completion of assessment,

have been converted to Seedling seed orchards. Similarly, the clonal trials have been assessed and converted to Clonal seed orchards, wherever possible. The details of various trials raised in respect of those species are provided at Table 14.

Table 14

Tree Improvement Trials

Species		Plus trees*	Provenance trials		Progenies trials		Clonal testing and development			
Scientific name	Native (N) or exotic (E)	Number	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
1. *Abies pindrow*	N	-	5	5	-	-	-	-	-	-
2. *Acacia auriculiformis*	E	23	7	30	-	-	-	-	-	-
3. *Acacia catechu*	N	52	12	283	-	-	-	-	-	-
4. *Acacia hybrid*	N	200	-	-		-	3	200	-	-
5. *Acacia leucophloea*	N	-	3	24	-	-	-	-	-	-
6. *Acacia mangium*	E	-	5	96	-	-	1	6	1	1
7. *Acacia nilotica*	N	410	16	28	-	-	-	-	-	-
8. *Acrocarpus fraxinifolius*	N	16	2	16	-	-	-	-	-	-
9. *Aegle marmelos*	N	-	2	10	-	-	-	-	-	-
10. *Ailanthus excelsa*	N	-	8	80	-	-	-	-	-	-
11. *Ailanthus grandis*	N	30			-	-	-	-	-	-
12. *Ailanthus triphysa*	N	-	5	--	-	-	-	-	-	-
13. *Albizia lebbeck*	N	-	2	13	-	-	-	-	-	-
14. *Albizia odoratissima*	N	-	1	--	-	-	-	-	-	-
15. *Albizia procera*	N	55	15	70	-	-	-	-	-	-
16. *Alstonia scholaris*	N		1	--	-	-	-	-	-	-
17. *Altingia excelsa*		27			-	-	-	-	-	-
18. *Amoora wallichii*	N	8	-	-	-	-	-	-	-	-
19. *Anogeissus latifolia*	N		5	--	-	-	-	-	-	-
20. *Aquilaria malaccensis*	N	-	-	-	-	-	-	-	-	-
21. *Artocarpus heterophyllus*	N	31	6	--	-	-	-	-	-	-
22. *Azadirachta indica*	N	937	47	57		30	-	-	-	-
23. *Bambusa balcooa*	N	12	7	-	-	-	5	12	-	-
24. *Bambusa nutans*	N	12	-	-	-	-	5	12	-	-
25. *Bambusa pallida*	N	12	-	-	-	-	5	12	-	-
26. *Bambusa tulda*	N	12	-	-	-	-	5	12	-	-
27. *Bambusa vulgaris*	N	1	-	-	-	-	-	-	1	1
28. *Bauhinia racemosa*	N	-	1	--	-	-	-	-	-	-
29. *Bombax ceiba*	N	33	11	62	-	-	-	-	-	-
30. *Boswellia serrata*	N	-	1	--	-	-	-	-	-	-
31. *Buchnania lanzan*	N	-	4	--	-	-	-	-	-	-
32. *Calophyllum inophyllum*	N	-	1	--	-	-	-	-	-	-
33. *Canarium resiniferum*	N	7	-	-	-	-	-	-	-	-
34. *Canarium strictum*	N	18	-	-	-	-	-	-	-	-
35. *Cassia fistula*	N	-	1	--						
36. *Casuarina equisetifolia*	E	411	56	67	1	1	5	18	3	3
37. *Casuarina junghuhniana*	E	16	3	2	-	-	4	16	1	1
38. *Cedrus deodara*	N	-	8	--	-	-	-	-	-	-

39. *Chloroxylon swietenia*	N	-	1	--	-	-	-	-	-	-
40. *Chukrasia tabularis*	N	20	2		-	-	-	-	-	-
41. *Cinnamomum cecidodaphne*	N	14			-	-	-	-	-	-
42. *Commiphora wightii*	N	-	1	--	-	-	-	-	-	-
43. *Cupressus torulosa*	N	-	2	--	-	-	-	-	-	-
44. *Dalbergia latifolia*	N	15	6	14	-	-	-	-	-	-
45. *Dalbergia sissoo*	N	537	52	13	3	70	8	30	1	1
46. *Dendrocalamus hamiltonii*	N	12	-	-	-	-	5	12	-	-
47. *Dillenia indica*	N	-	1	--	-	-	-	-	-	-
48. *Diospyros melanoxylon*	N	-	3	--	-	-	-	-	-	-
49. *Dipterocarpus macrocarpus*	N	153	3	-	-	-	-	-	-	-
50. *Dipterocarpus retusus*	N	17	-	-	1	17	-	-	-	-
51. *Duabanga sonneratioides*	N	70	2	28	-	-	-	-	-	-
52. *Endospermum chinensis*	N	9	-	-	-	-	-	-	-	-
53. *Eucalyptus camaldulensis*	E	424	224	21	9	26	59	109	123	20
54. *Eucalyptus grandis*	E	-	1	2	-	-	-	-	-	-
55. *Eucalyptus tereticornis*	E	300	11	6	17	5	60	4	300	
56. *Eucalyptus pellita*	E	10	1	1	1	1	1	1	1	1
57. *Eucalyptus urophylla*	E	-	3	8	-	-	-	11	-	-
58. *Eucalyptus occidentalis*	E	-	2	2	-	-	-	-	-	-
59. *Evodia lunu-ankenda*	N	-	1	--	-	-	-	-	-	-
60. *Ficus* spp.	N	-	11	--	-	-	-	-	-	-
61. *Fraxinus xanthoxyloides*	N	-	1	--	-	-	-	-	-	-
62. *Garcinia indica*	N	41								
63. *Gmelina arborea*	N	338	64	60	2	21	6	41	1	1
64. *Grewia tiliifolia*	N	-	1	--	-	-	-	-	-	-
65. *Gyrocarpus americanus*	N	-	1	--	-	-	-	-	-	-
66. *Haldina cordifolia*	N	-	6	--	-	-	-	-	-	-
67. *Hardwickia binata*	N	-	5	--	-	-	-	-	-	-
68. *Hevea brasiliensis*	E	4 548	--	-	-	-	-	344	163	12
69. *Holoptelea integrifolia*	N	-	1	--	-	-	-	-	-	-
70. *Hopea parviflora*	N	-	1	--	-	-	-	-	-	-
71. *Illicium griffithii*	N	30	-	-	-	-	-	-	-	-
72. *Jatropha curcas*	E	4 368	-	-	37	22	-	-	-	-
73. *Juglans regia*	N	-	5	--	-	-	-	-	-	-
74. *Leucaena leucocephala*	E	241	5	94	-	-	-	-	12	-
75. *Limonia acidissma*	N	40	3	48	-	-	-	-	-	-
76. *Madhuca longifolia*	N	50	1	--	-	-	-	-	-	-
77. *Mangifera indica*	N	172	1		-	-	-	-	-	-
78. *Melia azedarach*	N	-	3	--	-	-	-	-	-	-
79. *Melia dubia*	N	40	1	--	2	42	-	-	-	-
80. *Mesua ferrea*	N	8	1	8	-	-	-	-	-	-
81. *Michelia champaca*	N	30	2		-	-	-	-	-	-
82. *Mimusops elengi*	N	-	1	--	-	-	-	-	-	-
83. *Mitragyna parvifolia*	N	-	1	--	-	-	-	-	-	-
84. *Morinda tinctoria*	N	-	1	--	-	-	-	-	-	-
85. *Morus alba*	E	-	3	--	-	-	-	-	-	-

86. *Morus laevigata*	N	-	3	--	-	-	-	-	-	-
87. *Myristica* spp.	N	-	1	--	-	-	-	-	-	-
88. *Neolamarckia cadamba*	N	-	1	8	-	-	-	-	-	-
89. *Oroxylum indicum*	N	-	2	--	-	-	-	-	-	-
90. *Phoebe cooperiana*	N	1	-	-	-	-	-	-	-	-
91. *Phoebe goalparensis*	N	21	-	-	-	-	-	-	-	-
92. *Phyllanthus emblica*	N	-	33	31	-	-	-	-	-	-
93. *Picea smithiana*	N	-	2	--	-	-	-	-	-	-
94. *Pinus gerardiana*	N	-	1	--	-	-	-	-	-	-
95. *Pinus kesiya*	N	-	1	--	-	-	-	-	-	-
96. *Pinus patula*	E	56	2		-	-	-	-	-	-
97. *Pinus roxburghii*	E	303	31	16	-	-	-	-	-	-
98. *Pinus wallichiana*	N	-	4	23	-	-	-	-	-	-
99. *Podocarpus nerifolius*	E	-	1	--	-	-	-	-	-	-
100. *Pongamia pinnata*	N	568	-	-	13	22	-	-	-	-
101. *Populus ciliata*	N		8	--	-	-	-	-	-	-
102. *Populus deltoides*	E	-	-	--	-	-	3	640	20	8
103. *Prosopis cineraria*	N	218	11		-	-	-	-	-	-
104. *Prosopis juliflora*	E	-	3	12	-	-	-	-	-	-
105. *Prunus armeniaca*	E	152	-	-	5	17	-	-	-	-
106. *Pterocarpus dalbergioides*	N	42	-	-	-	-	-	-	-	-
107. *Pterocarpus marsupium*	N	-	9	-	-	-	-	-	-	-
108. *Pterocarpus santalinus*	N	-	4	--	-	-	-	-	-	-
109. *Rhododendron arboreum*	N	-	1	--	-	-	-	-	-	-
110. *Santalum album*	N	3	28	--	-	-	-	-	-	-
111. *Sapindus emarginatus*	N	-	1	--	-	-	-	-	-	-
112. *Schleichera oleosa*	N	-	1	--	-	-	-	-	-	-
113. *Shorea assamica*	N	35			-	-	-	-	-	-
114. *Shorea robusta*	N	50	3	50	-	-	-	-	-	-
115. *Sterculia urens*	N	-	4	--	-	-	-	-	-	-
116. *Strychnos nux-vomica*	N	-	1	--	-	-	-	-	-	-
117. *Swietenia macrophylla*	N	-	4	--	-	-	-	-	-	-
118. *Swietenia mahogani*	N	-	4	--	-	-	-	-	-	-
119. *Syzygium cumini*	N	1	16	--	-	-	-	-	-	-
120. *Tamarindus indica*	N		9	--	-	-	-	-	-	-
121. *Taxus wallichiana*	N		3	--	-	-	-	-	-	-
122. *Tecomella undulata*	N	15	14	13	2	40	-	-	-	-
123. *Tectona grandis*	N	1 330	42	78	2	34	-	-	-	-
124. *Terminalia arjuna*	N	14	5	11	-	-	-	-	-	-
125. *Terminalia bellirica*	N	17	4	--	-	-	-	-	-	-
126. *Terminalia chebula*	N	85	2	--	-	-	-	-	-	-
127. *Terminalia manii*	N	10								
128. *Terminalia myriocarpa*	N	64			-	-	-	-	-	-
129. *Tetrameles nudiflora*	N	3	-	-	-	-	-	-	-	-
130. *Thespesia populnea*	N	59								
131. *Vateria indica*	N	-	1	--	-	-	-	-	-	-
132. *Wrightia tinctoria*	N	-	1	--	-	-	-	-	-	-
133. *Xylia xylocarpa*	N	-	4	--	-	-	-	-	-	-
134. *Ziziphus mauritiana*	N	3	2	--	-	-	-	-	-	-

* List number of plus trees if programme is beginning and only first generation seed orchards have been established.

As a result of the ongoing tree improvement programmes, seed orchards have been established for many economically useful species. The seeds from these orchards are being supplied to the planting agencies, including farmers. The genetically improved seeds from these orchards are quite inadequate to meet the complete requirement of seeds, in respect of all the species that are planted. The details of seed orchards available for various species are provided at Table 15.

Table 15.

Seed orchards

S. No.	Species (scientific name)	Seed orchards*		
		Number	Generation**	Area
1.	*Abies pindrow*	-	-	37.00
2.	*Acacia auriculiformis*	1	-	1.00
3.	*Acacia catechu*	6	-	62.00
4.	*Acacia mearnsii*	1	-	4.00
5.	*Acacia nilotica*	2	-	13.00
6.	*Acacia occidentalis*	-	-	12.00
7.	*Acacias*	7	-	39.40
8.	*Adina cordifolia*	1	-	3.00
9.	*Altingia excelsa*	1		3.00
10.	*Ailanthus* spp	2	-	3.50
11.	*Albizia procera*	2	-	10.20
12.	*Acrocarpus fraxinifolius*	1		10.00
13.	*Artocarpus chaplasha*	1	1	0.80
14.	*Artocarpus* spp	1	-	2.00
15.	*Azadirachta indica*	6	-	12.85
16.	Bamboos	2	-	1.00
17.	*Bauhinia variegata*	1	-	3.00
18.	*Bombax ceiba*	4	-	28.24
19.	*Casuarina equisetifolia*	8	1,2	69.50
20.	*Casuarina junghuhniana*	1	1	1.50
21.	*Cedrus deodara*	-	-	36.00
22.	*Chukrasia tabularis*	2	-	2.00
23.	*Dalbergia sissoo*	27	1	411.60
24.	*Dipterocarpus griffithii*	1	1	1.00
25.	*Dipterocarpus* spp.	47	1	1.25
26.	*Duabanga grandiflora*	1		1.00
27.	*Eucalyptus camaldulensis*	12	1,2	21.50
28.	*Eucalyptus citrodora*	1	-	4.25
29.	*Eucalyptus globulus*	1	-	2.00
30.	*Eucalyptus tereticornis*	130	1,2	482.98

31.	*Ficus benghalensis*	-	-	5.00
32.	*Ficus micrantha*	-	-	37.00
33.	*Ficus religiosa*	-	-	5.00
34.	*Garuga pinnata*	1	-	3.00
35.	*Gmelina arborea*	30	1	418.40
36.	*Grevillea robusta*	1	-	1.00
37.	*Juglans regia*	-	-	38.00
38.	*Melia azedarach*	-	-	5.00
39.	*Michelia champaca*	2	-	7.00
40.	*Ougeinia oojenensis*	1	-	3.00
41.	*Paulownia* spp	1	-	5.00
42.	*Phoebe goalparensis*	1	-	1.00
43.	*Phyllanthus emblica*	9	-	126.50
44.	*Pinus carribaea*	1	-	5.00
45.	*Pinus kesiya*	-	-	1.50
46.	*Pinus roxburghii*	-	-	44.00
47.	*Pinus wallichiana*	-	-	36.00
48.	*Populus deltoides*	-	-	4.00
49.	*Pterocarpus dalbergiodes*	1	1	4.49
50.	*Pterocarpus marsupium*	-	-	4.00
51.	*Pterocarpus santalinus*	2	-	7.00
52.	*Santalum album*	2	-	23.60
53.	*Tamarindus indica*	1	-	432.00
54.	*Tectona grandis*	76	-	4572.11
55.	*Terminalia bialata*	1	1	0.20
56.	*Terminalia chebula*	1	-	9.00
57.	*Terminalia myriocarpa*	2	-	9.00
58.	*Terminalia procera*	3	1	1.20

*Seed orchards are plantations specifically planted and managed for seed production, not natural seed stands. * * Generation refers to 1st , 2nd, 3rd, etc., breeding cycle

Information on the ongoing tree improvement programmes is available in the form of Research reports, technical reports, annual reports and publications, which lie scattered in various government offices. There is no system of collection, collation, analysis and transmission of data related to tree improvement to the user agencies. For this purpose, the MoEF has recently sanctioned the ENVIS on FGR to be managed by the IFGTB.

4.2. Delivery/ deployment systems; availability of reproductive materials

The reproductive materials available from the seed orchards and vegetative multiplication gardens are now available for use by the farmers, forest departments and other research organizations. New varieties are being evolved and released for use. These are available only within the country, and so far no supply has been made internationally. Policy on this matter is yet to be taken. The details of the type of reproductive material available are at Table 16.

The improved reproductive material available in forestry were first classified in the country under the Scheme for certification of Forest Reproductive Material presented as a paper in 1972 at Symposium on Man-made Forests organized by the Society of Indian Foresters and later on recommended by National Commission on Agriculture for adoption by the States. This was later revised and issued in 1979 by the Government of India as 'Certification of Forest Reproductive Material in India (Revised Scheme 1979)'. The scheme classified the forest reproductive material as, (1) Source identified reproductive material, (2) Selected reproductive material, (3) Reproductive material from untested seed orchards, and (4) Tested reproductive material. The scheme was meant for implementation by the States, but in the absence of a legal backing, this could not be enforced.

For implementation of the abovesaid scheme, seed zoning was also done. The first attempt in India to create seed zones specifically to facilitate seed collection was taken up in 1978 by the IDPSPTI. This involved many considerations for a country the size of India, especially the wide variations in climatic conditions, soil, physiography and species distribution, besides the administrative setup in different states of the country. The country was divided into 147 seed zones for the purpose of seed collection, movement and tree improvement activities. However, in the absence of legal enforcement of the scheme, the seed zones were also not given the due importance. Now a Bill for enforcing this legally is pending before the Indian Parliament in the form of Forest Reproductive Material Certification Bill, 2008. Once this is passed and enacted, tree improvement would be invigorated in the country.

Along with the development of a national seed procurement and distribution system, the availability of the genetically improved seeds should also be augmented. The success in “Agriculture” is due to the improved seeds and their ready availability to farmers. Such a strategy is required to be adopted in forestry sector too, with a National Tree Seed Centre (NTSC) under ICFRE along with State Seed Centres (SSC) in research wings of SFDs. The NTSC would provide the required guidelines for handling of forestry seeds by the SSC. Ensuring genetic quality is possible by registering all the seed sources and documenting the same in the National Register of Seed Sources certified by the NTSC following the set guidelines and ensuring that the SSC would collect the seeds only from these sources. The NTSC can not only coordinate seed supply between the SFDs but also facilitate international seed exchange programmes. To increase the availability of quality seeds, besides the seed sources available with ICFRE and the forest departments, seed orchards are also to be established with the farmers and industries, in the form of Community Seed Orchards and Industrial Seed Orchards.

The plantation forests in India are dominated by monocultures of a few species like, *Eucalyptus*, *Tectona grandis,* Acacias*, Casuarina, Shorea robusta, Cedrus deodara, Pinus roxburghii, Pinus wallichiana, Gmelina arborea, Grevillea robusta*, etc., meeting the requirements of various industries. However, the average productivity of the plantations in India stands just at about 10 m^3/ha/yr., and this is not able to meet fully the raw material demand of the industries. The requirement of wood by the industries is steadily on the rise. The gap in the raw material supply to industries can be met to some extent by technology based plantations managed through industry-farmer linkage. Industrial agroforestry through a tripartite partnership among the research organizations supplying quality planting stock, farmers providing their land and the industries providing assured buy-back arrangements, would give a boost to the plantation forestry sector.

The plantation forestry has to tap the potential of hybrid forestry. At present the hybrids in use are those of Populus and Acacias, and those developed and under testing are those of Eucalyptus and Casuarinas. More emphasis should be given on production of hybrids and their use as clones, to utilize the hybrid vigour and increase the productivity.

Table 16

Type of reproductive material available

Species (Scientific name)	Type of material	Available for national requests only		Available for international requests	
		Commercial	Research	Commercial	Research
1. *Acacia catechu*	Seed	To Farmers	√	Policy yet to be decided	
2. *Acacia mangium* (Hybrid)	clone	To Farmers	-		
3. *Acacia nilotica*	Seed	To Farmers	√		
4. *Acacia senegal*	Seed	To Farmers	√		
5. *Azadiracta indica*	Seed	To Farmers	√		
6. *Bambusa vulgaris*	Clones	To Farmers	-		
7. *Casuarina equisetifolia*	Clones/Seedling	To Farmers	√		
8. *Casuarina junghuhniana*	Seedling/clone	To Farmers	-		
9. *Cinnamomum tamala*	Seed	---	√		
10. *Dalbergia sissoo*	Clones	To Farmers	-		
11. *Dendrocalamus membranaceous*	Rhizome bank	-	√		
12. *Eucalyptus camaldulensis*	Seedling/clone	To Farmers	√		
13. *Eucalyptus grandis*	Seedling/clone	-	√		
14. *Eucalyptus pellita*	Seedling/clone	-	√		
15. *Eucalyptus tereticornis*	Seedling/clone	To Farmers	-		
16. *Eucalyptus urophylla*	Seedling/clone	-	√		
17. *Eucayptus occidentalis*	Seedling/clone	-	√		
18. *Gmelina arborea*	Clones	To Farmers	-		
19. *Mangifera indica*	Seed/clonal	To Farmers	√		
20. *Pongamia pinnata*	Seed	To Farmers	√		
21. *Populus deltoides*	Cuttings	---	√		
22. *Taxus baccata*	Clones	---	√		
23. *Tectona grandis*	Seed	To Farmers	√		
24. *Thyrsostachys siamensis*	Rhizome bank	-	√		

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2. Madan Gopal and P.G. Pattanath. 1979. Certification of Forest Reproductive Material in India (Revised scheme, 1979). Seed zoning system followed in India. Indo-Danish Project on Seed Procurement and Tree Improvement.

CHAPTER 5

THE STATE OF NATIONAL PROGRAMMES, RESEARCH, EDUCATION, TRAINING AND LEGISLATION

The main objective of this section is to describe the state of national capacities in research, education, training and legislation as well as coordination and information mechanisms for forest genetic resources. The needs and priorities in each of these areas and the appropriate level of intervention- national, regional and/or global have been discussed. The areas covered include national programmes for forest genetic resources, national legislation, research, education and training, dissemination, coordination mechanisms and assessment of major needs in capacity building.

5.1 National Programmes

The management of forests is by the State governments, under the broad guidelines of the National Forest Policy, 1988. Therefore, any national forest programme has to be carried out by the States as far as management is concerned. On a large number of issues of national importance, national programmes exist. In 1999 with the assistance from FAO a National Forestry Action Programme (NFAP) was prepared. The NFAP (2000- 2020) made Action Proposals for Forestry Research and Technology, which included *in-situ* and *ex-situ* conservation of forest genetic resources. It also made specific recommendations on use of forest genetic resources to augment the supply of industrial wood (Anon., 1999). Forestry research is attended to by the ICFRE and also by the research wings of the SFDs, and is largely in terms of the National Forestry Research Plan (NFRP) which has a national character and helps avoid duplication of research (ICFRE, 1999). National Wildlife Action Plan (NWAP) (2002-2016) deals with the protection of flora and fauna in the Protected Area Network, and that indirectly deals with the FGR. National Biodiversity Action Plan (NBAP), 2008 and National Action Plan on Climate Change (NAPCC), 2008, Mangroves for the Future- National Strategy and Action Plan (MFF-NSAP), 2011 also deal with the conservation and use of biological resources, at national level.

The main institutions actively engaged in field work related to forest genetic resource conservation are the SFDs, under whose control all the forest areas are managed. They are the ones directly concerned with *in-situ* conservation of forest genetic resources. There are 28 States and 7 Union territories that have their own forest departments as custodians of the forests and their genetic resources. The management of forests is in the mandate of these departments, though certain areas are identified for Joint forest management (JFM) with the people of villages adjoining forests, covering certain limited areas of management. All the PAs where the biodiversity is

conserved, whose sub-set is the FGR are under the control of forest departments. The details of areas conserved *in-situ* is discussed elsewhere.

The forestry research organizations, Non-government organizations (NGOs) and wood based industries are mainly concerned with the *ex situ* conservation of forestry species of their interest. The ICFRE with its institutes located in different parts of the country maintains a large number of SPAs, seedling seed production areas, SSOs, CSOs, clone banks and VMGs, as a part of FGR conservation and use. The ICAR and its institutes concerned with agroforestry, also maintain the germplasm of forestry species used in agroforestry. The NBPGR, New Delhi maintains accessions of forestry species as seed collections. The Agricultural universities which conduct courses on forestry also maintain collections of forestry species in their *ex situ* conservation and tree improvement programmes. The Botanical gardens under the IBGN maintain forestry species in their collections all over India. The NBAP, 2008 envisages establishment of a botanical garden in each district. There are also NGOs, such as BAIF Research Foundation, private research organizations and nurseries and wood-based industries and their research wings that maintain collection of germplasm of forestry species. The details of the collections by all the institutions mentioned above have been discussed elsewhere under the chapter on *ex situ* conservation.

The SFDs engaged in *in situ* conservation are all government agencies. The ICFRE and the ICAR are also autonomous bodies of the government, engaged in *ex situ* conservation. The agricultural universities are under the administrative control of the State governments. The wood based industries, especially, pulp and paper mills that maintain germplasm collections of forestry species are both from private and government sectors, but a majority are from the private sector. The non-governmental organizations are private societies, trusts or co-operative societies. The list of institutions is provided in Table 17.

Table 17

Institutions involved with conservation and use of forest genetic resources

	Name of the institution	Type of institution	Activities or programme	Contact information
1.	Forest Research Institute, Dehradun	Government	Forest Tree improvement, Germplasm conservation	Director, Forest Research Institute, Dehradun. (fri.icfre.gov.in)
2.	Tropical Forest Research Institute, Jabalpur	Government	Forest Tree improvement, Germplasm conservation	Director, Tropical Forest Research Institute, Jabalpur. (tfri.icfre.gov.in)
3.	Arid Forest Research Institute, Jodhpur	Government	Forest Tree improvement, Germplasm conservation	Director, Arid Forest Research Institute, Jodhpur. (afri.icfre.gov.in)
4.	Himalayan Forest Research Institute, Shimla	Government	Forest Tree improvement, Germplasm	Director, Himalayan Forest Research Institute, Shimla. (hfri.icfre.gov.in)

			conservation	
5.	Rainforest Research Institute, Jorhat	Government	Forest Tree improvement, Germplasm conservation	Director, Rainforest Research Institute, Jorhat. (rfri.icfre.gov.in)
6.	Institute of Forest Productivity, Ranchi	Government	Forest Tree improvement, Germplasm conservation	Director, Institute of Forest Productivity, Ranchi. (ifp.icfre.gov.in)
7.	Institute of Wood Science and Technology, Bangalore	Government	Forest Tree improvement, Germplasm conservation	Director, Institute of Wood Science and Technology, Bangalore (iwst.icfre.gov.in)
8.	Institute of Forest Genetics and Tree Breeding, Coimbatore	Government	Forest Tree improvement, Germplasm conservation	Director, Institute of Forest Genetics and Tree Breeding, Coimbatore (ifgtb.icfre.gov.in)
9.	Central Institute of Medicinal & Aromatic Plants, Lucknow	Government	Medicinal plant conservation	Director, Central Institute of Medicinal & Aromatic Plants, Lucknow. (www.cimap.res.in)
10.	National Botanical Research Institute, Lucknow	Government	*Ex-situ* conservation and Bioprospecting	Director, National Botanical Research Institute, Lucknow.(www.nbri.res.in)
11.	Botanical Survey of India, Calcutta	Government	Survey of plants and *ex-situ* conservation	Director, Botanical Survey of India, Calcutta. (bsi.gov.in)
12.	Central Agricultural Research Institute, Port Blair	Government	*Ex-situ* conservation	Director, Central Agricultural Research Institute, Port Blair (cari.res.in)
13.	Central Plantation Crops Research Institute, Kasaragod	Government	*Ex-situ* conservation	Director, Central Plantation Crops Research Institute, Kasaragod (www.cpcri.gov.in)
14.	Central Research Institute on Dryland	Government	*Ex-situ* conservation, Plant breeding	Director, Central Research Institute on Dryland Agriculture (CRIDA), Hyderabad.

	Agriculture (CRIDA), Hyderabad			(www.crida.in)
15.	National Research Centre on Agroforestry (NRCAF), Jhansi	Government	*Ex-situ* conservation	Director, National Research Centre on Agroforestry (NRCAF), Jhansi (mirror.iasri.res.in)
16.	Indian Institute of Horticultural Research, Bangalore	Government	*Ex-situ* conservation	Director, Indian Institute of Horticultural Research, Bangalore (www.iihr.res.in)
17.	National Bureau of Plant Genetic Resources, New Delhi	Government	*Ex-situ* conservation	Director, National Bureau of Plant Genetic Resources, New Delhi (www.nbpgr.ernet.in)
18.	Kerala Forest Research Institute, Peechi	Government	*Ex-situ* conservation	Director, Kerala Forest Research Institute, Peechi. (www.kfri.org)
19.	Tropical Botanical Garden and Research Institute, Palode	Government	*Ex-situ* conservation	Director, Tropical Botanical Garden and Research Institute, Palode (www.tbgri.in)
20.	M.S. Swaminathan Research Foundation, Chennai	NGO	*Ex-situ* conservation	Executive Director, M.S. Swaminathan Research Foundation, Chennai. (www.mssrf.org)
21.	Foundation for Revitalization of Local Health Traditions, Bangalore	NGO	*Ex-situ* conservation	Director, Foundation for Revitalization of Local Health Traditions, Bangalore (www.iaim.edu.in)
22.	BAIF Development Research Foundation, Pune	NGO	*Ex-situ* conservation	Director, BAIF Development Research Foundation, Pune. (www.baif.org.in)
23.	Hindustan Newsprint Limited	Government	Forest Tree improvement, Germplasm conservation	Managing Director, Hindustan Newsprint Limited, Newsprint Nagar, Kottayam District, Kerala (www.hnlonline.com)
24.	Century Pulp and Paper	Private Sector	Forest Tree improvement	Managing Director, Century Pulp and Paper, Ghanshyamdham,

			Lalkua Distt – Nainital (www.centurypaper.org.in)
25. Orient Paper and Industries Ltd.	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, P.O. Amlai Paper Mills, Dist.:- Shahdol Madhya Pradesh (www.orientpaperindia.com)
26. The West Coast Paper Mills	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, The West Coast Paper Mills Ltd. Post Box No.5, Bangur Nagar Dandeli – 581 325, Karnataka (www.westcoastpaper.com)
27. The Sirpur Paper Mills	Private Sector	Forest Tree improvement	Executive Director, The Sirpur Paper Mills, Sirpur-Kaghaznagar Andhra Pradesh 504 296 (www.sirpurpaper.com)
28. Ballarpur Industries	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, Ballarpur Industries Ltd. First India Place, Tower C, Mehrauli - Gurgaon Road, Gurgaon, Haryana - 122002, India (www.bilt.com)
29. JKPaper Ltd.	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, JK Paper Mills, Jaykaypur, Rayagada, Orissa- 765 017 (www.jkpaper.com)
30. Andhra Pradesh Paper Mills (now merged with International Papers)	Private Sector	Forest Tree improvement	Managing Director, The A.P. Paper Mills Ltd., Rajahmundry, East Godavari Dist. Andhra Pradesh 533 105 (www.andhrapaper.com)
31. ITC Ltd.	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, ITC Limited - Paperboards & Specialty Papers Division, RB. No.4, Sarapaka Village, Bhadrachalam Andhra Pradesh 507 128
32. Wimco seedlings	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, Wimco Ltd. (Wimco Seedlings Division) R&D Centre, Bagwala, Rudrapur Distt. US Nagar (Uttaranchal) (www.wimcoseedlings.com)
33. Pragati Biotechnologies	Private Sector	Forest Tree improvement, Germplasm conservation	Managing Director, Pragati Biotechnologies, Clonal Research cum Production Centre Village & P.O. Dholbaha,

			District Hoshiarpur, Punjab144206. (www.eucalyptusclones.com)
34. Tamil Nadu Newsprint and Papers Ltd.	Government	Forest Tree improvement, Germplasm conservation	Managing Director, Tamil Nadu Newsprint and Papers Ltd., Kagithapuram, Karur, Tamil Nadu (www.tnpl.com)
35. Seshasayee Papers and Boards	Private sector	Forest Tree improvement, Germplasm conservation	Managing Director, Seshasayee Paper and Boards Limited, Pallipalayam, Cauvery R.S P.O Erode - 638 007 (www.spbltd.com)

5.2 Networks at national level

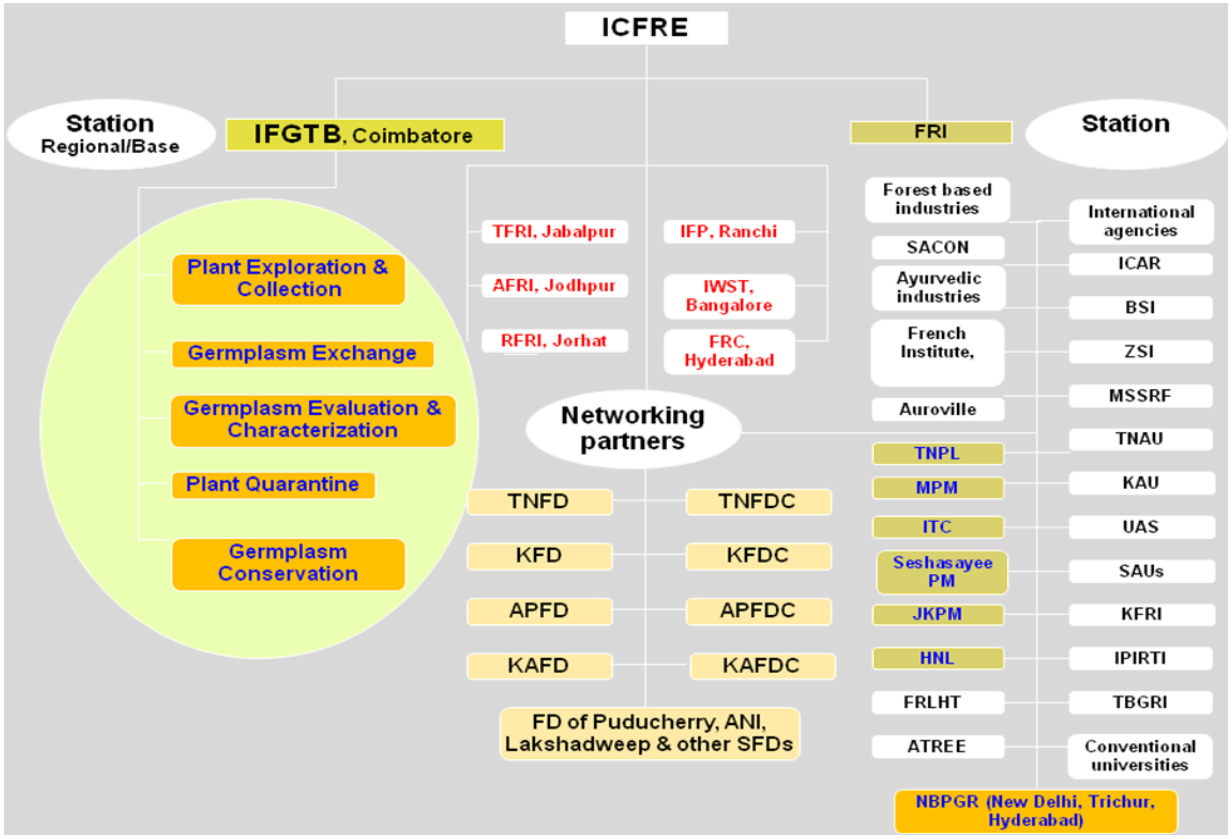
At national level the first network programme for forest genetic resources, involving the SFDs and the Forest Research Institute and its centres across the country, was the IDPSTI. Subsequently ICFRE has managed programmes on collection, documentation, evaluation and use of tree genetic resources available in India. Under the FORTIP (UNDP/FAO Regional Forest Tree Improvement Project) it procured germplasm of plantation species, such as Eucalyptus, Casuarina, Acacias, etc., and established provenance trials and progeny trials, which serve as the basis of the ongoing tree improvement programmes. Under the Planting Stock Improvement Programme (PSIP) of the Forestry Research, Education and Extension Project (FREEP) funded by the World Bank, ICFRE has established a large number of genetic resource stands. The details of these genetic resources are discussed elsewhere under *ex situ* conservation.

The country is part of the regional network, APFORGEN established in 2003 for the purpose of FGR conservation and use. Research organizations within the country were also partners in certain species specific networks, such as, International Neem Network, TEAKNET, the International Network on *Leucaena* Research and Development (LEUCANET), the International Network on Bamboo and Rattan (INBAR), etc. However, at national level no network has been developed, till recently, exclusively for the FGR.

In 2003 ICFRE established a NBFGR under its International Genetic Resource Programme (Katwal *et al*., 2003) but the same was not functional. The MoEF conceived a similar bureau recently and the same is to be made operational in the 12th Plan period (2012-17). As a precursor to that, a FGRMN has been constituted in ICFRE with the FRI, Dehradun and IFGTB, Coimbatore as the nodal agencies. The existing FGRMN has the Directors of the FRI and IFGTB as nodal officers. The "Chair of Excellence" for Forest Genetic Resources has been established at IFGTB, Coimbatore and will function from there to guide all activities related to FGR management.

The network has all the research institutions, universities, forest departments, wood based industries and NGOs as partners. The functions planned for the network are plant exploration and collection, germplasm exchange, germplasm evaluation and characterization, plant quarantine and germplasm conservation. The ongoing programmes on genetic improvement of species will be linked to the network. The network planned at IFGTB is shown below as a model. The national stakeholders have been included in the network. The planning process is done in a consultative

manner. Workshops have been conducted to prioritize the species to be handled. The modalities of implementation, such as, the legal framework, role of partners, and linkage with other national programmes on biodiversity or other genetic resources are yet to be worked out.



At present there is no exclusive legal framework governing the forest genetic resources. However, the legislations related to biodiversity conservation, sustainable use and access and benefit sharing (Biological Diversity Act, 2002) and the protection of farmers' rights and plant varieties (PPVFR Act, 2001) have implications on forest genetic resources. The collection of forest genetic resources from wild and their transport are regulated by the Indian Forest Act, 1927, Wildlife (Protection) Act, 1972 and various State Forest Acts. The trade and export of the resources is governed by CITES, in respect of the endangered resources.

Ideally the national forest genetic programme should work in tandem with the national programmes in agrobiodiversity, wild relatives of agricultural crops, development programmes especially those related to use of plant resources in industries and the environment conservation programmes related to reclamation of degraded areas, restoration of degraded forests, urban forestry, etc. The relationship with these programmes will have to be forged, as and when detailed action plans for the forest genetic resource management are evolved.

The national programme for forest genetic resources has commenced only recently in 2011. Funding for the same has been assured through a special grant from the MoEF and the major activities related to the programme will start only in 2012. The initial support is for infrastructure building in the form of laboratories and equipments and capacity building in the form of trainings, workshops and recruitment of personnel to manage the programme. The needs and priorities are consolidation of the information and resources already available, and then exploration of genetic variation in the forestry species already domesticated or in the process of domestication,

throughout the natural range of the species, exchange of germplasm with countries having the same species in order to widen the germplasm base, testing and characterization of the germplasm and its use in breeding programmes to evolve new varieties suited to various requirements of the user agencies. The first step should be establishment of wide germplasm assemblages, which would primarily be field gene banks, followed by seed banks.

The main challenge to maintain the national programme for genetic resources would be the availability of trained manpower. The ICFRE has a strength of 362 scientists and 665 supporting staff, and is just equivalent in strength to a large institute in any other part of the world. This council maintains 8 institutes, all understaffed and overworked. With multiple mandates to undertake, the focus on forest genetic resources would be lost, if these institutes are not strengthened in terms of manpower. The next major challenge would be the availability of land for establishment of field gene banks. This problem can be solved, if this is done collaboratively with forest departments and universities which own large extents of land. The collection of genetic resources across forests of the country would require assured mobility. This would be the next major challenge for the programme.

The challenges posed by lack of manpower of funds can be mitigated to an extent by working in a network mode, where the resources are shared. Though a network has been conceived, the functions of exploration, collection, characterization, exchange and use in breeding programmes are yet to start in the network mode.

5.3 Education, Research and Training

Financial allocation to forestry sector has always been less than 1% of the total budget of the government. Approximately 0.03% of the annual budget goes for conservation. Of this it is difficult to estimate how much goes towards forest genetic resources. It is miniscule compared to the amounts spent on other development sectors, or even other activities within the forestry sector. For instance in the allocation to Environment and Forests in the XI Plan period (2007-2012) which was Rs. 1 00 000 million, the allocation to R&D for conservation and development was just Rs. 3 000 million and to Conservation of Natural Resources and Ecosystems Rs. 6 000 million. These two components together, account for just 1% of the budget allocation to forestry sector. In the XII Five year Plan (2012-2017), the allocation is likely to be increased to 2.5 per cent of the budget. Under the Green India Mission, which is is one of the eight missions under NAPCC, funding is made available for afforestation, reforestation activities including research which would look into the FGR aspects also.

Forestry research draws funds from various other organizations also like the Department of Biotechnology or Department of Science and Technology under the Ministry of Science and Technology for projects related to biotechnology or climate change. The Ministry of Health through the NMPB funds projects related to medicinal plants. The Ministry of Agriculture through the NBM funds a large number of projects on bamboo cultivation and research. The ICAR also funds projects on agroforestry.

Forest genetic resource is not explicitly covered in any educational course in the country. It is part of the Forestry courses conducted in various agricultural universities. Some universities have specialization in Forest genetics and breeding at Masters level. Doctorate is awarded in subjects related to forest genetic resources and their conservation or use, in all the agricultural universities

and the Forest Research Institute University. The Universities offering forestry courses in the country are listed below:

1. Birsa Agricultural University, Ranchi, Jharkhand
2. CCS Haryana Agricultural University, Hisar, Haryana
3. Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh
4. College of Horticulture & Forestry, Pasighat, Arunachal Pradesh
5. CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh
6. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra
7. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra
8. Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan
9. FRI University, Dehra Dun, Uttarakhand
10. GB Pant University of Agriculture & Technology, Pant Nagar, Uttarakhand
11. Guru Ghasidas University, Bilaspur, Chattisgarh
12. HNB Garhwal University, Srinagar, Garhwal, Uttarakhand
13. Indira Gandhi Agricultural University, Raipur, Chattisgarh
14. Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh
15. Kerala Agricultural University, Thrissur, Kerala
16. Kumaun University, Nainital, Uttarakhand
17. Maharana Pratap University of Agriculture & Technology, Jhalawar, Rajasthan
18. Navsari Agricultural University, Navsari, Gujarat
19. North Eastern Regional Institute of Science & Technology, Nirjuli, Arunachal Pradesh
20. Orissa University of Agriculture & Technology, Bhubaneshwar
21. Punjab Agricultural University, Ludhiana, Punjab
22. Sam Higginbottom Institute of Agriculture, Technology & Sciences (Formerly Allahabad Agricultural Institute - Deemed University), Allahabad
23. Sher-e-Kashmir University of Agricultural Sciences & Technology, Shalimar, J&K
24. Tamil Nadu Agricultural University, Coimbatore
25. University of Agricultural Sciences, Bangalore, Karnataka
26. University of Agricultural Sciences, Dharwad, Sirsi, Karnataka
27. Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, West Bengal

The research organizations mentioned above are engaged in research related to conservation and sustainable use of forest genetic resources. The ongoing research projects largely fit into the categories of exploration, documentation, characterization, conservation, breeding programmes and utilization of forest genetic resources.

There is a need for creating institutes dealing exclusively with certain species of great economic importance, such as, *Tectona grandis, Shorea robusta*, Pines, pulpwood species, etc. All the institutes under the ICFRE have to establish a division dealing exclusively with the FGR. The Working Plans of the SFDs have to devote attention to the FGR in the management of forest areas. The SFDs should also constitute a cell at the headquarters to deal with the FGR. More programmes on exploration should be organized to understand the genetic diversity of the economically important species, and to speed up their domestication process.

5.4 National Legislation

The country is signatory to many conventions and treaties that are related to various aspects of biodiversity conservation, sustainable use and access and benefit sharing, besides protection of intellectual property rights. The provisions cover the forest genetic resources also. The main treaties, agreements and conventions are listed below:

1. Convention on Biological Diversity (CBD)
2. Convention on International Trade in Endangered species of fauna and flora (CITES)
3. FAO International Undertaking on Plant Genomic Resources
4. International Treaty on Plant Genetic Resources for Food and Agriculture
5. WTO Agreement on the Application of Sanitary and Phytosanitary Measures
6. Agreement on trade-related aspects of Intellectual Property Rights System (TRIPS)
7. International Plant Protection Convention
8. IUCN Global strategy for Plant conservation

The following legislations have been enacted over the past 10 years relevant to the conservation and sustainable use of forest genetic resources, besides equitable sharing of benefits:

a. Biological Diversity Act, 2002 and Biological Diversity Rules, 2004. This Act primarily aims at regulating access to biological resources and associated traditional knowledge so as to ensure equitable sharing of benefits arising out of their use, in accordance with the provision of Article 15 of the CBD.
b. Protection of Plant varieties and Farmers' Rights Act, 2001 and Protection of Plant varieties and Farmers' Rights Rules, 2003 deal primarily with the protection of plant breeder's rights over the new varieties developed by them and the entitlement of farmers to register new varieties and also to save, breed, use, exchange, share or sell the plant varieties, which the latter have developed, improved and maintained over many generations.
c. Plant Quarantine (Regulation of import into India) Order, 2003
d. The Patent Second Amendment Act 2002 and Patent Third Amendment Act 2005, provide for exclusion of plants and animals from the purview of patentability (Section 4e); exclusion of an invention which in effect is traditional knowledge from patentability (Section 4p); mandatory disclosure of the source and geographical origin of the biological material in the specification when used in an invention (Section 8D); and provision for opposition to grant of patent or revocation of patent in case of non-disclosure or wrongful disclosure of the source of biological material and any associated knowledge.
e. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006- Recognizes and vests the traditional rights to forest dwelling communities over access to forest goods and occupation in forest lands.

There is no legal framework for FGR strategies, plans and programmes. However, there are Action Plans related to various aspects of FGR. For instance, a National Policy and Macrolevel Action Strategy on Biodiversity was formulated in 1999. Thereafter, under the UNDP (United Nations Development Programme) / GEF (Global Environment Facility) sponsored National Biodiversity

Strategy and Action Plan (NBSAP) Project from 2000 to 2004, 33 state level, 10 ecoregion level, 18 local level, and 13 thematic action plans were prepared. On the basis of these action plans, a final technical report of NBSAP was prepared. In 2008, a National Biodiversity Action Plan (NBAP) has been prepared, broadly based on the evaluation of existing legislations, regulatory systems, implementation mechanisms, existing strategies, plans and programmes, using the report of NBSAP project as one of the inputs. This serves as the framework for biodiversity related matters, including FGR, at present.

In the absence of an exclusive legislation governing the forest genetic resources, the legislations related to biodiversity and the plant genetic resources, are applied to the FGR, as well. In view of the special nature of the FGR, such as, their location in forest areas that are remote and inaccessible, ownership with the State, traditional knowledge available with the forest dwelling tribals and the problems associated with biopiracy, a special legislation can be enacted. The various needs related to such legislation are tabulated in Table 18.

Table 18.

Needs for developing forest genetic resources legislation

Needs	Priority level			
	Not applicable	**Low**	**Moderate**	**High**
Improve forest genetic resources legislation	Not applicable as no legislation exists exclusively for FGR	--	--	--
Improve reporting requirements	Not applicable	--	--	--
Consider sanction for noncompliance	Not applicable	--	--	--
Create forest genetic resources targeted regulations	--	--	--	√
Improve effectiveness of forest genetic resources regulations	Not applicable as regulations do not exist for FGR exclusively	--	--	--
Enhance cooperation between forest genetic resources national authorities	--	--	--	√
Create a permanent national commission for conservation and management of forest genetic resources	--	--	--	√
Other (Please specify)	--	--	--	--

5.5 Information systems

Traditional Knowledge Digital Library (TKDL) is a digital repository of traditional knowledge especially about medicinal plants and formulations used in Indian systems of medicine, set up in 2001 as a collaborative effort between the Council of Scientific and Industrial Research (CSIR) and Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (Dept. of AYUSH), Ministry of Health & Family Welfare, Government of India. The objective of the library is to protect the ancient and traditional knowledge of the country from exploitation through bio-piracy and

unethical patents, by documenting it electronically and classifying it as per international patent classification systems.

Biodiversity information system (BIS) has been created by the Department of Biotechnology and the Department of Space. The entire spatial and non-spatial data on Indian plant biodiversity has been organized and is available in BIS, with its major components i.e BIOSPATIAL (Biodiversity spatial infromation), PHYTOSIS (Plant information system), FRIS (Forest resource information system) and BIOSPEC (Biodiversity conservation spatial decision support system). The Western Ghats biodiversity information system is a collaborative endeavour of Jawaharlal Nehru Centre for Advanced Scientific Research, Indian Institute of Science and Foundation for Revitalization of Local Health Traditions. The University of Agricultural Sciences, Bangalore has created databases called the Jeevsampada and Sasya Sampada which have species browsing and search system for medicinal plants.

The National Research Centre for Agroforestry (NRCAF) as a part of the Integrated National Agricultural Resources Information System (INARIS) has developed a database called the 'agroforestryBASE' and maintains bibliographic databases on *Populus, Eucalyptus, Pongamia, Jatropha, Madhuca, Simmondsia, Euphorbia, Hardwickia, Simarouba, Leucaena* and *Garcinia*. The databases on *Ricinus*, Teak, *Prosopis*, Sandal and Neem are under construction.

The ICAR maintains databases under the National Information Sharing Mechanism on the implementation of the Global Plan of Action (NISM-GPA) for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, which is a regional cooperative project of FAO in the Asia Pacific region. Though this network of 114 institutions is primarily concerned with agriculture, it also includes forestry species of importance for agroforestry and oil-seed yielding trees. The NISM database has information on 1 243 plants of which there are many forestry species.

The ENVIS Centre on FGR envisaged at the IFGTB, shall in future, act as a repository of all information on the subject. The ENVIS Centres are collecting literature on the assigned subject, establishing linkages with all information sources, responding to user queries and establishing a data bank on the subject. The Centres are also coordinating with the focal point at the Ministry of Environment and Forests for supplying relevant, adequate and timely information to the users, helping the focal point to build up an inventory of information material, identifying the information gaps and bringing out newsletters/ publications on the assigned subject for wide dissemination.

5.6 Public Awareness

Documentation of the FGR is the prime necessity. Publications highlighting the role of FGR in the socio-economic well being of the people have to be made. More research is required on exploration of FGR. The genetic diversity of many species is yet to be unraveled. Provenance delimitation, assessment of the genetic diversity, assemblage of germplasm, characterization and use in breeding programmes have to be carried out for many of the economically important species. While awareness on biodiversity is increasing, many fail to understand the subtle difference between biodiversity and FGR. More education and training programmes on FGR are required even for the forestry professionals who are managers of the FGR. The forestry scientists and the extension

personnel also need a sound understanding of the importance of FGR conservation and use, and accordingly training and orientation programmes are required to be organized.

There is a need for targeted FGR information, to be disseminated to the forest managers, forest dwelling people, forest dependent industries and the general public, in order to promote conservation and sustainable use of FGR and equitable sharing of benefits arising out of its use. Training programmes on identification, non-destructive harvest, processing and storage of harvested material and marketing, have to be imparted to all the stakeholders. The awareness raising needs are tabulated at Table 19.

Table 19

Awareness raising needs

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	--	--	--	√
Other (Specify)	--	--	--	

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CHAPTER 6

THE STATE OF REGIONAL AND INTERNATIONAL AGREEMENTS AND COLLABORATION

6.1 International Agreements

The MoEF, Government of India is the nodal agency for the agreements with United Nations Development Programme (UNDP), World Bank, United Nations Industrial Development Organization (UNIDO), United Nations Conference on Sustainable Development (UNCSD), United Nations Environment Programme (UNEP), Global Environment Facility (GEF) and regional bodies like Economic and Social Commission for the Asia and the Pacific (ESCAP), South Asian Association for Regional Cooperation (SAARC), South Asian Cooperative Environmental Programme (SACEP), Asian Development Bank (ADB), International Treaty on Plant Genetic Resources (ITPGR) and European Union (EU) in all matters related to Environment and Forests. India has participated actively in all the major international events related to Biodiversity Conservation over the past decades and has ratified all the major Biodiversity and Environment related global conventions. India has also taken up agreement with World Intellectual Property Organization (WIPO) on Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC) and Substantial Patent Law Treaty (SPLT). The IGC mainly attempts to establish a database.

India is among the 193 Contracting Parties to CBD and has developed legislation on accessing of Forest Genetic Resources. India has always played a very active role in the implementation of CITES, at a national, regional and international level. It has been both a member of the Standing Committee and a host country for a meeting of the Conference of the Parties. Other major agreements having a bearing on biodiversity in which India is a party are Ramsar Convention on Wetlands, World Heritage Convention, the Bonn Convention on Migratory Species, United Nations Framework Convention on Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD), UN Commission on Sustainable Development (UNCSD), World Trade Organization (WTO), International Treaty on Plant Genetic Resources (ITPGR) for food and agriculture and UN Law of the Seas. MoEF, Govt of India has bilateral MoUs/Agreements with 12 countries viz. Austria, China, Germany, Iran, Israel, Netherlands, Russia, Tajikistan, Turkmenistan, USA, UK and Vietnam on various environmental issues.

India is one amongst the seven Asian countries to have signed an agreement with FAO to participate in the regional cooperative project “Establishment of the National Information Sharing Mechanism on the Implementation of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (PGRFA) in Asia and the Pacific Region”. The project aims at promoting the implementation of Global Plan of Action (GPA) at national and regional levels and mechanism for gathering and sharing information, as well as priority setting for GPA implementation.

6.2 International Collaboration

India has collaborated with various international agencies for the purpose of research as well as management of FGR. India is a party to major Multilateral Environmental Agreements on biodiversity conservation and management. ICFRE has carried out FGR related research activities through funding from and in collaboration with FAO, CIRAD, DANIDA, DFSC, FRED, FORTIP, UNDP and World Bank, in the past. ICFRE is interacting with various international organizations, such as the International Plant Genetic Resources Institute (IPGRI) on specific issues related to FGR conservation (Katwal *et al*., 2003). India is a member of various species specific networks in the world. For instance, it is a member of the International Neem Network of the FAO, under which five international provenance trials have been established in India. It is also a member of the International Network for Bamboo and Rattan (INBAR) which is an intergovernmental organization for improving the social, economic, and environmental benefits of bamboo and rattan. Workshops and training courses are being organized by INBAR in India (INBAR, 2011). It is a part of the Teaknet of Asia Pacific Region established with the support of FAO to promote interactions and share information among the stakeholders of teak wood sector. Indian Institute of Forest Management, Bhopal and Indian Institute of Science, Bangalore are members of the Asia Forest Network (AFN), Philippines which is dedicated to supporting the role of communities in protection and sustainable use of Asia's forests (AFN, 2011).

Under the Man and Biosphere (MAB) Programme of UNESCO, thirteen Biosphere Reserves have been established in the country of which the Sunderban (West Bengal), Gulf of Mannar (Tamil Nadu) and the Nilgiris have been included in the World Network of Biosphere Reserves. India is participating in the IUCN-MFF (Mangroves for the Future) initiative, under which it has prepared a national strategy and action plan.

India is a part of the APFORGEN (Asia Pacific Forest Genetic Resources Programme) Network. India hosted the APFORGEN country coordinators meeting in 2006. It conducted a national consultative workshop on FGRs in 2007 at IFGTB, Coimbatore. A training workshop on Conservation and Management of FGR was also conducted at IFGTB, for the member countries of APFORGEN, in 2010. India also proposes to host the 5th International Conference on Casuarinas, in 2013, which will of interest to the members of APFORGEN network.

Under the auspices of UNESCO, World Heritage Biodiversity Programme for India (WHBPI) is being implemented to protect the World Heritage Sites of Manas, Kaziranga, Keoladeo and Nanda Devi, which are also repositories of FGR.

An overview of the main activities carried out through the various networks mentioned above, and the outputs are listed at Table 20.

Table 20

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

Network name	Activities*	Genus/species involved (scientific names)
International Neem Net work	To establish International Provenance Trials of Neem and their evaluation.	*Azadirachta indica*
TEAKNET	To enhance the capacity of International Stakeholders particularly teak growers, traders, researchers and policy makers in responding effectively to the changing social, economic and environmental needs.	*Tectona grandis*
INBAR	For improving the social, economic, and environmental benefits of bamboo and rattan. Workshops and training courses are being organized by INBAR in India	Bamboos and Rattans
FORTIP	To enhance the productivity of economically important forestry species.	*Eucalyptus* spp., *Casuarina* spp., *Acacia* spp.
IUCN-MFF	To promote investment in Coastal Ecosystem Conservation	Mangroves
ITTO-ICFRE	Establishment of a network to facilitate collection, processing and dissemination of statistics pertaining to tropical timber and other forestry parameters in India.	Timber species
Asia Forest Network, Philippines	Protection and sustainable use of Asia's forests.	
APFORGEN	Develop national FGR programmes for the participating countries	52 species
Forest Genetic Resources Management Network (FGRMN), India	Collection, evaluation, conservation, documentation and exchange of germplasm of important tree species in ICFRE, Forest departments, Research organizations and Industries	30 species

In the area of tree improvement of economically important species, India had collaboration with various international organizations, such as FAO, UNDP and World Bank. Major international programmes like Indo Danish Project on Seed Procurement and Tree Improvement in 1970's and the Forestry Research, Education and Extension Project funded by the World Bank project in 1990's were implemented by ICFRE. In the IDPSTI major emphasis was laid on the improvement of valuable

species like teak, rosewood, *Gmelina* and *Bombax*. Through the World Bank project, provenance trials at national level for various species like *Dalbergia sissoo*, pines and acacias have been conducted. In addition, international provenances of neem, *Casuarina* spp., eucalypts and acacias have been assembled in ICFRE institutes, SFDs and Forest Colleges. The assemblages have been sourced through collaboration with CSIRO Australia especially in case of Eucalyptus and Casuarina and have been the source for SPA, SSO, CSO and VMG. Improved seeds/ planting stock from these resources have been made available for planting to user agencies and have thus helped in afforestation of large tracts of land.

Coordinated by IUCN, a project titled "Mangroves for Future (MFF): a strategy for promoting investment in Coastal Ecosystem Conservation" involving eight countries in South and South East Asia and Western Indian Ocean has been taken up. Through aid from IDRC and FORTIP a number of research programmes have been conducted for conservation of bamboo resources by the ICFRE and State Forest Research Centres and the Forest Departments in different states in the country. In 2010, the United States Forest Service, with the support from United States Agency for International Development (USAID) and in collaboration with the MoEF has initiated a programme for addressing opportunities and challenges related to Reduced Emissions from Deforestation and Forest Degradation (REDD) including the role of increasing forest carbon stocks in India through the Sustainable Landscapes funding. SFDs of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra, in consultation with the Foundation for Revitalization of Local Health Traditions (FRLHT) and with the support of DANIDA and UNDP have established 54 MPCAs. Travelling workshops in mangrove forests of South and Central Africa, Oceania, West and Central Africa were conducted by M.S. Swaminathan Research Foundation, Chennai, India in collaboration with ITTO.

The Ministry also deals with the appraisals, approvals and monitoring of Forestry Projects implemented in the States with funding from external agencies viz. Japan International Cooperation Agency (JICA), AFD (French Development Agency), World Bank (WB), etc. for promoting afforestation, rehabilitation of degraded forest areas, water and soil conservation measures, farm forestry, agro forestry with the aim to increase forest and tree cover as well as to augment availability of fuel wood and fodder, improve the livelihood opportunities and quality of life of the villagers adjoining forests, strengthening joint forest management institutions to ensure people's participation, besides encouraging tree growing on private land as well as greening of the urban areas (MoEF, 2011). The MoEF functions in partnership with a number of institutions for developing and implementing national strategies on conservation and sustainable use of biological diversity. India chaired the Like Minded Megadiverse Countries (LMMCs) for two years (2004 to 2006) and coordinated the activities of this group focusing particularly on access and benefit sharing issues under the CBD.

In a country like India with vast natural resources and diversity, the extent of effort required for FGR conservation is enormous. Thus, for effective conservation and management of FGR, networking is essential. This network would primarily be used for the the following activities:

- Coordination and promotion of *in situ* and *ex situ* conservation of FGR
- Evaluation and characterization of FGR
- National database for documentation and information of FGR
- Exchange of genetic material and information at national, regional and international level

- Enhancement of public awareness of the need to conserve FGR.

There is also a need to strengthen capacities for research and development related to FGR in the country. Infrastructural facilities throughout the country should be improved by enhanced and continual allocation of monetary resources for conducting advanced research. Human resource development of scientific/ technical personnel through national and international trainings will also lead towards efficient forest genetic resource conservation and management.

While lots of efforts have gone in the assemblage of germplasm, limited efforts are being taken for phenotypic, biochemical and molecular characterization of germplasm for different traits like pest, drought and salt tolerance, better wood traits and medicinal properties especially in indigenous species. Understanding the state of diversity with respect to these traits would require coordinated efforts of domain experts from different laboratories working on the modern phenomic, genomic, proteomic and metabolomic technologies. Infrastructure facilities and human resource development in these areas in forestry research institutes through collaborative ventures is therefore important.

High priority need to be given for raising awareness on the needs for international collaboration and networking for enhancing *ex situ* management and conservation, research, education and training and information management and early warning systems for forest genetic resources. For efficient coordination and management of FGR at national and regional levels, APFORGEN should evolve mechanisms to strengthen and support networking, information sharing, capacity-building and research endeavours by establishment of regional centres of Bioversity International in the representative countries. Some of these activities may require international collaboration in future. India wouldalso be interested in sharing its know-how on tree breeding with less experienced countries through training of young scientists.

The needs and priorities for international collaboration in various activities related to FGR management are listed at Table 21.

Table 21

Awareness raising needs/ 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		√		
Any other priorities for international programmes	√			

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CHAPTER 7

ACCESS TO FOREST GENETIC RESOURCES AND SHARING OF BENEFITS ARISING OUT OF THEIR USE

7.1 Access to forest genetic resources

7.1.1 Regulations with respect to access and benefit sharing of forest genetic resources

The Convention on Biological Diversity (CBD) recognizes bioresources as territorial asset and determining terms of accessing them, subject to their national legislation. India is among the 193 Contracting Parties to CBD and enacted the Biological Diversity Act, 2002 for assessing biodiversity and associated traditional knowledge (TK), and also for sustainable use of its components and fair and equitable sharing of benefits arising out of their utilization. For a national legislation on access and benefit sharing (ABS) to be effective, its recognition at the international level is essential so as to provide enough clarity and appreciation in user countries and also to support an effective monitoring mechanism for proper realization of the equity benefits within the country. India is a party to the Nagoya Protocol on Access to Genetic Resources and the fair and equitable sharing gof benefits arising from their utilization to the Convention on Biological Diversity, shortly called the Nagoya Protocol, and a national legislation is likely to be brought in on the model proposed in the protocol. Regulating access to bio-resources is considered the most common mechanism for sharing of benefits, arising from their authorized use, but it is expected that the benefit sharing terms are the most important, subject to which approval for access is granted. Legislation should be encouraging greater use of these bio-resources rather than posing barriers to their availability to users. If this movement is to make a real headway, this can be done by setting an example through more effective implementation of the national legislation on ABS and by setting up appropriate checks and balances while putting in place an efficient monitoring system.

7.1.2 Limit to access and movement of forest genetic resources into or out of the country

The legislation enacted by the country is not limiting but regulating the access and movement of forest genetic resources in/out of the country. The Indian government has enacted legislation for promoting conservation and sustainable use of country's biological resources and ITK while also meeting national obligations under international agreements like CBD, ITPGRFA and WTO-TRIPS. Though these initiatives are highly appreciable, there exists enough scope for making these measures better focused and more effective. A promising development in this context is the adoption of Nagoya Protocol. To bring the biological resources from other countries, India as a signatory to IPPC 1952 (modified 1997) has framed sufficient quarantine and phytosanitary measures which are also of regulatory nature and put no artificial barrier to trade.

7.1.3 Action to improve access

There is no difficulty right now in either accessing of our bioresources or sharing the resources from other nation. However, for collaborative research programmes bilateral/multilateral agreement and Material Transfer Agreement (MTAs) with inbuilt benefit sharing mechanism have to be worked out case by case. National Biodiversity Authority (NBA) and State Biodiversity Boards (SBB) are required to consult the Biodiversity Management Committees (BMC) on any decision regarding access and use of biodiversity within the jurisdiction of BMC. Ultimately BMC is the owner and custodian of bioresources within its jurisdiction.

7.2 Sharing of benefits arising out of the use of forest genetic resources

7.2.1 Mechanism for recognizing intellectual property rights related to forest genetic resources

Authorized access to biological resources is required prior to seeking Intellectual Property Rights (IPR). Any person seeking any kind of IPR in or outside of India for any invention/technology/product or process based on any biological resource (or associated information) obtained from India, is required to obtain prior permission of the NBA. In addition, the Patent (Amendment) Act, 2002, requires the patent applicant to disclose the source and geographical origin of the used biological material in the patent application, when used in an invention. Cultivars developed from the wild FGR are covered under the PPV & FR Act 2001, which protects the rights of both farmers and breeders.

7.2.2 Mechanisms of sharing benefits arising out of the use of forest genetic resources

Initially effort was done to bring in legislation. However, after Nagoya Protocol the efforts were stopped. Now, legislation based on Nagoya model is due. In the mean time Biodiversity act serves the purpose to certain extent. It is not mandate on the part of state governments to establish Biodiversity Management committee within a time frame. BMCs are the ultimate beneficiaries, any sharing of benefit process. For ensuring Access and Benefit Sharing (ABS), India has taken significant legislative measures by NBA in accordance with the provision of the CBD. The PPV&FR Act, 2001 and the PPV&FR Rules 2003, have been framed to provide measures to protect plant breeder's rights over extant varieties and farmer's rights to register new varieties, conserve, breed, use, exchange, share or sell the plant varieties, improved and maintained over many generations. The Patent Second Amendment Act 2002 and Patent Third Amendment Act 2005, for exclusion of plants and animals from the purview of patentability exclusion of an invention which in effect is traditional knowledge from patentability mandatory disclosure of the source and geographical origin and provision for opposition to grant of patent or revocation of patent in case of non-disclosure or wrongful disclosure of the source of biological material. Recently, the Government of India has enacted the The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 for empowering the tribal communities and other forest dwellers to have unhindered enjoyment of their traditional rights over the forest products at the same time imposing a duty on them in the conservation of forest and in the protection of FGR. However, the impact of this legislation is yet to be assessed.

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CHAPTER 8

THE CONTRIBUTION OF FOREST GENETIC RESOURCES TO FOOD SECURITY AND POVERTY ALLEVIATION

Forest Genetic Resources have the potential to emancipate people out of hunger and mitigation of poverty by supplying the most basic needs for sustainable development of the forest dependent communities. FGR in India have made adequate contributions providing economic, social and environmental benefits. Forests can provide a crucial contribution to Millennium Development Goals especially in achieving the environmental sustainability, poverty eradication and women empowerment. The trends indicate that planted forests and trees outside forests will also provide an increasing share of forest products.

8.1 Food security

India has high population pressure on land and other resources to meet its food and development needs. The natural resource base of land, water and bio-diversity is under severe pressure. The massive increase in population (despite the slowing down of the rate of growth) and substantial income growth, demands additional food sources annually, besides significant increases needed in the supply of livestock, fish and horticultural products. Edible wild fruits, bamboo seeds and wild legumes have played a very vital role in supplementing the diet of the rural communities. Tribal communities and ethnic tribes use wild edible plant species, including roots and tubers, leafy green vegetables, bulbs and flowers, fruits, seeds and nuts. In Andhra Pradesh, around 58 percent of *Madhuca* flowers and seeds and 17 percent of tamarind fruit collected by tribals are consumed by them. Some of the important fruit yielding woody species are *Artocarpus, Aegle, Emblica, Limonia acidissima, Mangifera, Syzygium, Zizyphus* and Tamarind. These resources are utilized by the local household and also form a major income source for the forest dependent communities.

8.2 Poverty reduction and livelihood support

It is estimated that 275 million poor rural people in India—27 percent of the total population—depend on NTFPs for at least part of their subsistence and cash livelihoods. This dependency is particularly intense for half of India's 89 million tribal people, the most disadvantaged section of

society, who live in forest fringe areas. According to an estimate the NTFP sector alone is able to create about 10 million workdays annually in the country (GoI, 2011).

NTFPs are obtained from about 3 000 species in the country and form an important source of livelihood for communities, particularly tribals and rural poor living adjacent to forests. In India, NTFPs contribute an income equivalent of US$ 2.7 billion per year and absorb 55% of the total employment in the forestry sector. Moreover, 50% of forest revenues and 70% of forest based export income come from NTFPs (Chauhan *et al*., 2008). They provide 50% of the household income for approximately one-third of India's rural population. About 70 percent of NTFPs are collected from Maharashtra, Madhya Pradesh, Bihar, Odisha and Andhra Pradesh, states that are home to 65 percent of the country's tribal population. The major forest-based activities generating employment and income include sale of firewood and fodder, rearing of livestock (grazing in and/or collecting fodder from forests), collection and processing of NTFPs and forest-based handicrafts and cottage industries. The income generated has been channeled by the rural families to cater the primary educational requirements. Some of the forest based industrial opportunities include mat making, preparation of *Terminalia chebula* concentrate and *Madhuca indica* syrup, oil extraction from *Shorea*, *Azadirachta* and *Pongamia*, production of leaf plates, *Phyllanthus* and *Mangifera* pickles.

Details of ten major NTFPs collected during 2005-06 are honey – 101 200 MT, myrobalans (*Terminalias*)-132 250 MT, sal (*Shorea robusta*) seeds – 709 700 MT, mahua (*Madhuca* spp.) seeds and leaves – 697 600 MT, neem (*Azadirachta indica*) seeds – 115 000 MT, gums including gum karaya (*Sterculia urens*) - 41 063 MT, bamboo - 4 716 600 MT, beedi (*Diospyros melanoxylon*) leaves - 360 000 MT, lac - 30 000 MT and resins - 175 135 MT (ICFRE, 2010).

Gum of *Acacia nilotica* and *Sterculia urens* are primarily for the export market, where a wide range of industries use the semi-processed product to produce finished retail goods. India is the world's largest exporter of *Sterculia urens* gum. It is the most important NTFP procured by Girijan Co-operative Corporation, Andhra Pradesh accounting for about one half of total procurement, and it is a major source of income for almost 12 000 tribal people. Exports have declined in recent years, due in large part to a loss of trees because of the widespread use of non-scientific and harmful tapping methods.

The undisclosed indigenous knowledge on medicinal trees held by the tribal communities is one of the valuable resources integrated with biodiversity. Protecting indigenous knowledge would benefit in treatment of ailments, reduction in child mortality rate and improvement of maternal health, when the modern healthcare systems are inaccessible and uneconomical for the forest dependents. Few most important species include *Azadirachta indica*, *Saraca asoca*, *Strychnos nux-vomica*, *Terminalia* spp. and *Taxus baccata*.

Tribal households depend heavily on livestock husbandry in several states of the country because livestock keeping generates a continuous stream of income and employment. Tree genetic resources supplement the cattle feed as well as in animal healthcare. Some of the fodder trees provide nutritious feed to the livestock population include *Leucaena leucocephala*, *Acacia nilotica, Albizia amara, Ailanthus excelsa* and *Ziziphus*.

Forest dependent communities are involved through societies, cooperatives in cultivation, in collection and marketing of forest produce. Many forest departments in the country support such activities through specialized initiatives as production, processing and marketing are complex issues to be handled. The Tribal Cooperatives Marketing Development Federation of India (TRIFED) under the Ministry of Tribal Affairs, GOI serve the interest of the tribal community and work for their socio-

economic development by undertaking retail marketing of tribal products. TRIFED also conducts skill up-gradation training and capacity building of minor forest produce (MFP) gatherers. Further, India being the sixth largest producer of honey in the world TRIFED has taken the initiative to create a "Wild Honey Network" for coordination and linkage among stake holders in wild honey and to develop the market of wild honey in an organized manner (http://www.tribesindia.com/). Some of the important woody plants support wild honey production is mangroves, *Pongamia pinnata*, *Azadirachta indica* and *Acacia*.

Gender plays a major role in forest based livelihood and in sustainable utilization of forest produce. Rural women are responsible for half of the world's food production and produce between 60 and 80 percent of the food in many developing countries. In Uttar Pradesh, India, a study showed that women obtained 33 to 45 percent of their income from forests and common land, compared with only 13 percent in the case of men. Chipko movement led primarily by the rural women could save the forests in Uttar Pradesh, Uttaranchal, Rajasthan, Himachal Pradesh, Bihar and Karnataka. As part of its Livelihood Development Project, the Tripura Bamboo and Cane Development Centre (TRIBAC) is assisting 350 tribal women in organizing self-help groups (SHGs). TRIBAC is providing skills training to these women to enable them to produce high quality agarbatti (incense sticks). In collaboration with the Indian Institute of Technology, Mumbai, Konkan Bamboo and Cane Development Centre (KONBAC), equipped tribal women working as bamboo artisans to make high-quality roti baskets, sold in cosmopolitan markets. A study conducted in West Bengal on Joint Forest Management (JFM) suggests gender-sensitive planning for rural community driven forest management programmes is a favourable way to increase women's income and reduce the time women spend searching for forest produce and completing ancillary tasks, such as processing. Women in villages with a female-headed local forest management unit were found to be the major contributors to their family's income received from forest sources after the programme was initiated.

Several States have initiated State Minor Forest Produce (Trading & Development) Co-Operative Federations with an objective to promote trade and development of NTFP. Main tasks of the Federation are i) Collection and trade of nationalized minor forest produce such as *Diospyros melanoxylon* leaves, *Shorea robusta* seed, *Terminalia chebula and g*ums of *Sterculia*, *Anogeissus* and *Acacia*, ii) Collection and trade of non-nationalized minor forest produce including medicinal and aromatic plants with assured market, iii) Promotion of minor forest produce based processing units, iv) Conservation, development and sustainable utilization of minor forest produce, and v) Promotion of cultivation of minor forest produce species including medicinal, aromatic and dye yielding plants. These efforts have shown tremendous potential for livelihood of forest dwelling communities. The details of species that are important for food security or livelihoods are furnished in Table 22.

Table 22

Tree and other woody species that are important for food security or livelihoods**

S.No	Species		Use for food security	Use for poverty reduction
	Scientific name	Native/ Exotic		
1	*Acacia catechu*	N		yes
2	*Acacia nilotica*	N		yes
3	*Aegle marmelos*	N	yes	
4	*Ailanthus excelsa*	N		yes
5	*Albizia amara*	N		yes
6	*Anogeissus latifolia*	N		yes
7	*Antiaris toxicaria*	N		yes
8	*Aquilaria malaccensis*	N		yes
9	*Artocarpus lakoocha*	N	yes	
10	*Azadirachta indica*	N		yes
11	*Bahaunia* sp	N		yes
12	*Bambusa* spp	N and E	yes	yes
13	*Bombax ceiba*	N		
14	*Buchanania lanzan*	N	yes	
15	*Butea* spp	N		yes
16	*Calamus* spp	N		yes
17	*Cedrus deodora*	N		yes
18	*Cinnamomum zeylanicum*	N	yes	
19	*Commiphora* spp	E		yes
20	*Diospyros melanoxylon*	N	yes	yes
21	*Phyllanthus emblica*	N	yes	
22	*Eucalyptus* spp	E		yes
23	*Ficus* spp	N	yes	
24	*Garcinia* spp	N		yes
25	*Grewia* spp	N	yes	
26	*Juglans regia*	E		yes
27	*Limonia acidissima*	N	yes	
28	*Leucaena leucocephala*	E		yes
29	*Madhuca indica*	N	yes	
30	*Mangifera indica*	N	yes	
31	*Manilkara* spp	N	yes	
32	*Myristica* spp	N	yes	yes
33	*Pongamia pinnata*	N		yes
34	*Quercus* spp	E		yes
35	*Rhododendron arboreum*	N		yes
36	*Schleichera oleosa*	N		yes
37	*Shorea robusta*	N		yes
38	*Sterculia urens*	N		yes
39	*Strychnos nux-vomica*	N		yes

40	*Syzygium cumini*	N	yes	
41	*Tamarindus indica*	N	yes	
42	*Terminalia* spp	N		yes
43	*Ziziphus* spp	N	yes	

**** The list of species given in table 4 is also important for livelihood and food security.**

8.3 Future Interventions

In the recent times the field of forest genetic resources is undergoing major changes wherein the FGR are not only viewed for tree improvement but also for multiple forest based services. Forests play critical roles in environmental sustenance by mitigating climate change, biological diversity conservation, gene resources for enhanced agriculture productivity, maintaining perpetual water resources, erosion control and soil protection, sustaining and changing land productivity, protecting coastal and marine resources, providing renewable energy resources, in consequence to enhanced urban environment.

National level database on precise baseline genetic information and demand and supply of various FGRs for the forest based biological industries should be targeted. Processing units for various minor forest products and state regulated trade has to be strengthened. Promotion of cultivation and up gradation of skills on processing has to be intensified. An umbrella organization exclusively for FGR management with appropriate linkage with SFDs, research institutions, universities and forest based industries has to be created for systematic updation of data. Encouragement of regional co-operations and networking of FGR improvement would lead to economic and social advancements. Hence, development of shared activities on common priority species, establishment of regional repositories of FGRs, exchange of germplasm and scientific knowledge on the status of important FGRs would support conservation. Globally scientific advances in frontier technologies (genomics, bioprospecting, DNA barcodes, cryotechnology) needs to be shared for meeting the regional demands. Mutually acceptable legal commitments required to be tailored for ensuring equitable utilization of forest genetic resources of the participating countries.

The sub-group on NTFP under the Planning Commission Working Group on Natural Resource Management discussed the issues, challenges, potential, and scope in developing the NTFP sector in the country and recommended the following strategies to be adopted for this purpose with a total budgeted amount of Rs.6590 crores for the 12th Plan period from 2012 to 2017 (GoI, 2011).

- Resource management through conservation of all genotypes including of RET species; development of sustainable harvesting protocols; resource augmentation and development; zone wise inventory of NTFPs; zone wise prioritization/ selection of species for conservation, development and harvesting (CDH) ; pilot initiatives followed by a cluster based approach for further development of NTFPs; and SFM including revision of Working Plan Code, Certification and CBNRM.
- Better opportunities in marketing through Minimum Support Price (MSP) ; mechanism for market intelligence and information system; efficient Certification system for improved trade;revolving fund for primary collectors and their institutions; value chain development by

aggregation; primary processing, grading, branding and certification; eco- services of NTFP such as Herbal ecotourism and local enterprise development; and encouraging corporate sector involvement- contract farming, infrastructure development, resource augmentation.

- Capacity building through formation and strengthening of local institutions; special training of front line staff and ToT; strengthening & restructuring existing institutions; modular training for primary collector, grower, entrepreneurs and traders; exposure visits of relevant stakeholders; and user friendly IEC materials.
- Expediting Research & Development activities through strengthening existing potential National/State R&D institutions; undertaking state of art research on NTFPs; prime focus on developing new/alternate marketability for single market NTFPs, low value high volume NTFPs, silviculture and conservation biology of NTFPs; tapping the concept of Payment for Ecosystem Services (PES); and study on impact of nonanthropogenic factors like climate change.
- Ensuring an enabling policy environment through formulation of a national level comprehensive policy; convergence of schemes implemented by different Ministries; establishment of an apex body such as NTFP Development Board and similar state level bodies; empowerment and strengthening of local institutions; ensuring better Access and Benefit sharing mechanism with legal provision; facilitating a compatible and uniform tax structure & transit rule; exemption of VAT; special compensatory support for NTFP crop failure; and introducing new schemes for NE region, mountain areas and Left Wing Extremism (LWE) affected states.

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