1.11.12

Research, Capacity Development, Extension and Monitoring for FGR

The effective conservation of FGR is not possible in the absence of requisite essential support of desired research, capacity development, monitoring, education and awareness. Despite its immense significance, explicit research, training, education, extension and monitoring programs focusing on FGR in India have been greatly lacking. However, varied priority aspects of conservation of FGR are being covered as a part of wider forestry research, education, capacity development, extension, and monitoring by the various forestry institutes and other allied organizations, primarily working under the MoEFCC. They have evolved over a long period of time. Brief details on these thematic activities are presented below:

1.11.12.1

Research on FGR

The foundation for Forestry research in the country was founded 158 years ago with establishment of the British Imperial Forest School in 1864 by Dietrich Brandis. The School was designated and renamed as the Imperial Forest Research Institute in 1906 under the British Imperial Forestry Service. It was moved to the present campus of FRI in 1929 and renamed after the country's independence. The forestry research in India evolved from an initial thrust on the production forestry focusing on select timber and other commercially important species. This phase based on silviculture continued for almost 90 years or so and during this phase, prominent disciplines of Forest Botany, Silviculture, Forest Entomology, Wood Science, Forest Pathology and Forest Products have developed. All these disciplines are not only the backbone for the wider subject of forestry but have also made notable contribution towards the description and documentation of forest diversity across the country, timber production, forest protection from pests and pathogens, and inventory of forest products including NTFPs and their management. In this phase, foundations for botanical garden, arboretum, bambusetum, and herbarium besides development of timber mechanics and engineering including wood preservation, seasoning and working; education; and extension were laid. Around 1960s, the emphasis of forestry research gradually shifted towards forest ecology, soil science, chemistry, physiology, biotechnology and genetics and a wide range of research studies were undertaken focusing on phytosociology, soil chemistry, biomass production, productivity, plant growth, seed biology, tissue culture, tree improvement, and sustainable management of forests. This second phase lasted for about 30 years prior to the enactment of WPA, 1972; FCA, 1980; and EPA, 1986; formulation of NFP, 1988; and signing of UNCBD in 1992. The thrust of researches in the second phase provided direction for conservation forestry. Nearly past four decades or the recent phase witnessed the emergence of newer disciplines/ themes of conservation of biodiversity. climate change, forest genetic resources, ecosystem services, and ecosystem-based forest management. All these disciplines/ themes have immensely contributed for enhanced understanding of FGR, and efforts towards in situ and ex situ conservation. Additionally, modern tools (Geographic Positioning System-GPS, portable biosensors, Unmanned Aerial Vehicle-UAV, DNA sequencer), technologies (IT, RS and GIS, DNA fingerprinting, bioinformatics) and techniques (prediction modelling for climate vulnerability, landscape genetics), concurrently developed during the recent phase and made notable contribution to the overall advancement of forestry research. Thus, the concerted multidisciplinary efforts towards forestry research over one and a half century have provided a strong foundation for the newer agenda on the conservation of FGR.

Specifically, the global recognition of FGR probably began for the first time around the second half of the nineteenth century with the advent of concepts of Mendelian inheritance, genes, genetic variation, and heredity in organisms leading to the emergence of 'genetics' as a new discipline. Prior to that, humanity believed that living things inherit traits from their parents and these observations were used to improve crop plants and animals through selective breeding. It was soon realized that natural selection will only cause evolution if there is enough genetic variation in a population, and by following the earlier common hypothesis of 'blending inheritance', genetic variance would be rapidly lost, making evolution by natural or sexual selection implausible. Since the development of an understanding of genetics and the nature of heritable materials, research on domestication of trees and tree improvement has evolved globally and nationally. As a result, the provenance trials for teak and pine were initiated at the Imperial Forest Research Institute (presently, FRI), Dehra Dun in 1920s. Subsequently, FRI, ICFRE and its institutes, ICAR, and other forestry/ agriculture universities and private entities have initiated relevant research and domestication of a large number of tree species in collaboration with SFDs. The improved reproductive material available in forestry were first classified in the country under the scheme for certification of Forest Reproductive Material in 1972 and later revised and issued in 1979 by the GoI as 'Certification of Forest Reproductive Material (FRM) in India (MoEF, 2012). Initially, the tree improvement programs undertaken in the country mainly concentrated on increase in volume of timber. Subsequently, the breeding program has advanced to improve the pulping or wood quality, pest tolerance, disease resistance, etc. ICFRE has developed comprehensive strategies for improvement of several timber and other commercially important tree species. In the process, the ICFRE institutes have not only assembled germplasm of various species but also carried out provenance trials, created seed

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orchards and vegetative multiplication gardens, and released new varieties. In 1978, the Indo Danish Project on Seed Procurement and Tree Improvement (IDPSPTI) for the first time created 147 seed zones specifically to facilitate seed collection, movement and tree improvement activities (MoEF, 2012). In the absence of legal enforcement of the scheme for certification of FRM, the seed zones were not given due importance. 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. ICFRE and its institutes have provided information on ongoing tree improvement programs in the form of research reports, technical reports and other publications, which are largely scattered, as presently there is no system of collection, collation, analysis and transmission of information/ data related to tree improvement to the user agencies.

As stated earlier, the NFRP guides the priority for forestry research while ICFRE steers research activities in this field across various institutes under its umbrella and other related organizations. Subsequent to the the first national level network program - IDPSPTI for FGR, the ICFRE has managed varied programs on collection, documentation, evaluation, and use of tree genetic resources. The country is a part of the regional network of research institutes in the Asia Pacific, APAFRI, established in 1995, and also of APFORGEN since 2003. Research organizations within the country have also been active partners in select species specific networks *viz.*, International Neem Network, TEAKNET, LEUCANET, INBAR, etc. (MoEF, 2012). With ICFRE as the lead agency, a 20-year national program for conservation and development of FGR (2015-2035) supported by the CAMPA fund, MoEFCC actually commenced in the FY 2016-2017 for implementation of the pilot project in the Himalayan State of Uttarakhand by FRI, Dehra Dun.

This book as an output of the pilot project summarizes varied researches carried out on FGR during 2016-2022. Prior to the pilot project on conservation of FGR, forestry institutions under the umbrella of ICFRE and other allied specialized institutions (FSI, BSI, WII, IIFM, etc.) besides forestry/ agriculture universities and the State level forestry institutes (e.g., SFRI, Madhya Pradesh; KFRI, Kerala) have been undertaking research on documentation of diversity in FGR, trends in forest cover under different forest types, seed behavior, tissue culture, tree improvement, in situ and ex situ conservation of biodiversity, and characterization based on chemical, molecular and pathological attributes.



Capacity Development for Conservation of FGR

On the lines of forestry research, specialized forest training for professional foresters concurrently commenced during the British regime and necessary infrastructure was developed. Initially, forest personnel were trained overseas in UK and other European countries for nearly four decades, prior to the establishment of Indian Forest College (IFC) in 1938 at FRI campus, Dehra Dun. The IFC was renamed as the Indira Gandhi National Forest Academy (IGNFA) in 1987. Since the inception of forest training programs during the colonial period, a large number of National/ State level governmental and non-governmental organizations have come up and they have been contributing towards capacity enhancement of forest officials, primarily engaged in conservation of forests for multiple objectives in accordance with the global obligations and national level priorities and commitments towards forests, biodiversity, environment, improved rural livelihoods and sustainable development. Other target groups including policy and decision makers, scientists, law enforcement agencies, NGOs, CBOs and communities are also being covered under regular and short term specialized/ thematic courses of varying duration by various institutions. Prominent amongst them are: IGNFA, ICFRE and its institutes (FRI, HFRI, AFRI, RFRI, IFP, TFRI, IFB, IWST and IFGTB), FSI, WII, IIFM, IIRS, CASFOS, and State Forest Service Colleges. The RT Division of MoEFCC sponsors compulsory training programs for Indian Forest Service (IFS) officers availing facilities and expertise of varied institutions across the countries. The IGNFA imparts rigorous training to IFS probationers in a wide range of disciplines relevant to forestry and prepares them to undertake varied jobs during their professional career whether it is field based managing FDs/ Circles in the assigned State/ UT or managing PAs besides roles of policy and decision making, research, education, training, etc. Likewise, CASFOS and other SFS Colleges in the country provide regular training to SFS probationers and also conduct short term thematic training courses/ workshops. Specialized institutions (WII, FSI, IIFM, IIRS, etc.) have also been making notable contribution towards the agenda of capacity development relevant to forestry, wildlife management, and biodiversity conservation. The FRI Deemed University (FRI-DU), IIFM, WII, IIRS, Salim Ali Center for Ornithology and Natural History (SACON) have been conducting Master's and Ph.D. degree programs in the subjects of Forestry, Environmental Management, Wood Science and Technology, Cellulose and Paper Technology, Forest Management, Wildlife Science, Heritage Conservation and Management, and Ornithology and thereby making direct and significant contribution towards the capacity enhancement required to deal with the multidiscipline science of FGR and preparing a pool of young scientists and researchers to cater to the needs relevant to documentation, characterization and conservation of FGR. In addition, a network of countrywide forestry/ agriculture universities and institutes also contribute towards higher education. Certainly, varied educational and professional training programs by multiple institutions would need to incorporate and provide desired thrust to the emerging requirements of FGR in their ongoing capacity development activities/ initiatives.

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1.11.12.3

Extension Activities for Conservation of FGR

Majority existing national/ state level institutions involved in forestry research and training and allied organizations, and also the SFDs have been conducting a wide range of activities relevant to forestry awareness and extension. They have been hosting innovative programs on the: International Forestry Day, International Biodiversity Day, World Environment Day, Earth Day, World Heritage Day, Wildlife Week, etc. including publicity and awareness campaigns on TV and print media. The agricultural universities in particular have been organizing annual fairs for farmers, incorporating extension activities and awareness on agroforestry. All concerned institutions and organizations including SFDs those have been involved in extension and awareness on matters related to forests, biodiversity and environment are required to augment and strengthen their ongoing activities with a clear focus on the various dimensions of FGR.

1.11.12.4

Monitoring of FGR

An explicit, comprehensive and focused monitoring of FGR by any central nodal agency and its supporting lower hierarchical units is yet to be planned and initiated. However, a large number of international, regional, national, and state level organizations have been monitoring the status, programs and activities relevant to FGR. The FAO-CGR has much earlier initiated a program at the global level so as to develop an insight on the status of FGR by collecting information from member countries and seeking periodic country reports. As a result, the FAO-CGR was able to bring out the informative global report on the State of The World's Forest Genetic Resources in 2014 that facilitated the development of Global Plan of Action for FGR The ITTO Tropical Timber Market (TTM) Report, an output of the ITTO Market Information Service (MIS) published every two weeks provides market trends and trade news from around the world, as well as indicative prices for over 400 tropical timber and added-value products. As substantial FGR across the country contribute towards timber and added value products, ITTO's contribution is valuable from the perspective of conservation of FGR. The IUCN as well as BSI have been undertaking an assessment on categorization of RET species including FGR. The most significant contribution on monitoring of country/ state/ forest type/ district wise Forest Cover, canopy density classes, growing stock, NTFPs, regeneration status, intensity and extent of forest fires, extent and trends in change of forest cover in tiger reserves, etc. biennially by FSI through ISFR provides a valuable insight on FGR at the broader scales. WII has been carrying out All India Monitoring of Tigers, Copredators, Prey and Habitat in tiger range States on a 4-year interval since 2006. Each detailed report conveys the holistic and diagnostic situation on in situ conservation in a considerable extent of PAs/ MFs. Moreover, most co-predators, prey and associated faunal diversity representing different taxonomic groups have vital role to play in pollination, dispersal and germination of seeds of FGR that indirectly helps in maintaining their diversity and abundance. ICFRE periodically brings out the Forest Statistics for the country including an insight on forest offenses. conveying the extent of illegal activities which might be impacting FGR. The FRLHT and NMPB generates useful information on quantities of medicinal plants collected and trade in them. Since, a large number of FGR contributes towards medicinal plants, such information by these two agencies is of relevance. At the state level, SFDs and Forest Development Corporations through periodic monitoring collect valuable information on production of species-wise timber, NTFPs, offences, seed collection, nursery plants, afforestation, reforestation, etc. and much of this information is useful from the perspective of conservation of FGR. The existing forest laws require mandatory preparation of Working Plan (WP) for each of the Forest Division and a revision every 10-year. The WPs are now being prepared/revised based on the National Forest Working Plan Code, 2014 which itself is comprehensive in the sense that it mandates field level assessment on forest composition (trees, shrubs, herbs, climbers, orchids, grasses), forest stock mapping, growing stock, regeneration status, NTFPs, wildlife, resource dependence, etc. Most information is, thus, obtained for forest beats, blocks, ranges, and overall division. The revision exercise stipulates repeat field data collection in some extent of the same areas covered under the previous plan while adequate sampling in new areas. This way, the sequential WPs decade after decade are not only important source of baseline information on varied aspects of FGR but also help in providing an insight on important trends. The time has matured to devise and develop a comprehensive monitoring of FGR in each FD.

Country's Reports on FGR

Conservation of FGR is a pre-requisite for ecosystem-based forest management and requires a holistic approach at various hierarchical levels (gene, species, ecosystem, landscape, state, national, regional and international). The FAO-CGR through IPGRI started focusing on forest tree species database-REFORGEN in 1993 and establishment of regional networks. After the UNCBD, the FAO-CGR in 1995 broadened the mandate to cover all components of biodiversity of relevance to food and agriculture, while in 2007 had emphasized for an urgent need to conserve and sustainably use FGR and included an agenda on the preparation of SOW-FGR. Thus, the FAO-CGR and the regional networks like APAFRI/ APFORGEN started collecting country reports on the status of FGR so as to prepare a consolidated report of the world and region, respectively. The APFORGEN released first South and South East Asian country reports in collaboration with IPGRI and FAO that included first formal comprehensive country's report by India on FGR highlighting the status of FGR; national conservation programs and management; role of ICFRE in conservation of FGR; production, use and future requirements for genetically superior propagules; research and development in genetic resources; provenance trials, Plus trees, seed orchards, tissue culture for mass propagation; relevant legislations, etc. (Luoma-aho et al., 2004; Katwal et al., 2004). The second country's report on FGR authored by Mandal (2008) formed a part of the proceedings of APFORGEN coordinator's meeting held at Dehra Dun in 2006 (Hong and Sim, 2008). This report included details on national policies and legislations relevant to FGR, organizations in the arena of FGR conservation, scientific reports by different organizations and research findings, National Biodiversity Strategy and Action Plan, protected areas, botanical gardens, etc. The third sequential country's report on conservation and management of FGR prepared in 2009 included vital information on the status of FGR including forest cover, NTFPs, medicinal plants, bamboo resources, legal framework, national programs, in situ and ex situ conservation, role of ICFRE, training, etc. (Rawat and Ginwal, 2009; Jalonen et al., 2009). The detailed country report on the State of FGR prepared by IFGTB on behest of the MoEF in 2012 submitted to FAO for the publication of SOW-FGR included an account on the forestry sector and the status of FGR while providing a list of 272 priority species for the country and forest species actively managed for productive aims. In addition, the report highlighted 195 prominent tree and other woody species providing environmental services and social values; a list of 261 threatened species; in situ and ex situ conservation; and national programs on research, education, training and legislation (MoEF, 2012). Furthermore, a national level action plan on FGR conservation and usage including the establishment of the National Bureau on Forest Genetic Resources (NBFGR) in the country prepared by Nagarajan (2013) as a part of his assignment as the Chair of Excellence based at IFGTB reviewed the state of FGR in the country and proposed a comprehensive strategy for conservation of FGR by highlighting the need to: (a) establish NBFGR; (b) initiate a national coordinated tree improvement program; and (c) start a national forest seed project towards bringing in a timber revolution and to mitigate climate change. The proposed plan primarily focused on improvement of selected tree species of paper and pulp value. This ambitious plan was considered and deliberated at higher levels of ICFRE and the Central Ministry.

The above para reveals that the formal recognition and dialogue on FGR at the global level, commenced around 1995 as the FAO-CGR at that time has broadened its mandate to include all aspects of biodiversity and the regional network- APAFRI was also established in 1995. Certainly, India as a megadiverse country was also actively participating in such deliberations whether at the global (FAO-CGR) or the regional (APAFRI) level. ICFRE, being the apex body responsible for forestry research across the country was representing in the regional/global level consultative processes. As a follow up, the ICFRE vide its order of 26 November, 2002 decided to create the National Bureau on Forest Genetic Resources (NBFGR) at ICFRE, Dehra Dun and set up a Cell to work out the modalities. Thus, a seed towards the creation of a national level agency for FGR was sown. Prior to this, concerns regarding assessment, management, and conservation of FGR were attended through research projects supported by the Council and implemented by various forestry research institutions under its umbrella. Planned and strategic efforts could be initiated only in 2003 after the set up of Cell for the purpose. Despite repetitive efforts between 2003-2010 by way of submitting a detailed proposal to the MoEF and deliberations with the policy and decision makers, desired support for setting and operationalization of NBFGR was not coming forward for the want of committed funding sources. After a gap of nearly seven years, the MoEF decided to initiate and strengthen FGR activities in the form of Forest Genetic Resource Management Network (FGRMN)' at two institutions (FRI and IFGTB) concurrently and allocated One Time Seed Grant (OTSG) of Rs. 175 million. The FGRMN activities focused on collection, documentation, characterization of FGR and their conservation in collaboration with SFDs, ICFRE institutes and other national organizations besides establishment of ex situ germplasm banks/ repositories. A meagre amount of Rs. Eight million was released in 2015-2016 and further funding under OTSG could not be received. Availing this small grant, a national repository of Poplar germplasm with more than 300 clones was established at FRI and essential equipment procured are being used for storage of valuable germplasm and characterization. The IFGTB appointed Dr. K. Gurumurthy as Chair of Excellence under FGRMN and during his four-month assignment submitted an approach paper for FGRMN. Later, Dr. S. Nagarajan, Ex-Director, IARI and Chairperson, PPVFRA was appointed as the Chair of Excellence of FGRMN and at the end of his six-month assignment submitted a report in July, 2013 for creation of NBFGR at ICFRE, which was further sent to the MoEF for consideration and

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approval/ funding. The proposals incorporated by Dr. Nagarajan could not find budgetary support from ICFRE as well as the MoEFCC until the end of 2015. The envisaged activities for FGR remained at the lowest ebb during the intervening period (2002-2015). After this gap, the FRI prepared a comprehensive National Program on Conservation and Management of FGR for the entire country with a total outlay of Rs. 510 million and submitted to the Ad.hoc CAMPA Fund under the MoEFCC. The Ministry reviewed the project and sanctioned to establish a Center of Excellence (CoE) of Forest Genetic Resources at FRI and initiating the activities of exploration, documentation, characterization and conservation of FGR initially in the Himalayan State of Uttarakhand, as a pilot demonstration state with the budgetary outlay of Rs. 86.6 million over a period of five years (2016-2021).



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Knowledge Gaps, Problem Statement and Key Questions

Above descriptive introductory account narrating the progress made on the conservation of FGR and accomplishments so far at the global as well as India's level has aptly highlighted that Forest Genetic Resources - the genetic diversity present in thousands of forest tree and other woody species on the Earth constitute an intergenerational resource of vast social, economic and environmental significance. Hence, effective conservation of FGR through appropriate actions and policies assure the continued existence, evolution and availability of these resources for present and future generations. Both the genetic resources themselves and the practice of their conservation are essentially dynamic. FAO has for several decades acknowledged the importance of FGR and the SOW-FGR based on information provided by 86 countries, and the final outcome in the form of Global Plan of Action has identified strategic priority areas and actions for conservation, sustainable use and development of FGR.

Although India has been active partner of FAO/ APFORGEN and contributing periodic country reports to them, and having one of the internationally acclaimed and oldest forestry research organizations i.e., FRI; SFDs as custodians of forests and responsible for their management; ICFRE with a network of countrywide institutions; BSI for botanical exploration and floristics; and other reputed national/ state level organizations contributing on varied aspects of FGR, a well-articulated and comprehensive national level strategy and agenda for the conservation of FGR in the country neither has been formulated nor programs and projects in this direction could garner the desired support at the national level until 2015. Hence, efforts for FGR remained Ad.hoc and piecemeal for a long period. As a result, there are gaps in the knowledge, and problems in conservation of FGR besides pertinent research questions.

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1.11.14.1

Knowledge Gaps

Adequate management of FGR requires the availability of accurate knowledge and information on ecosystems, species and the intraspecific variation. Access to information is also often a constraint. Knowledge gaps relevant to FGR pertain to (i) information, (ii) processes and technologies, and (iii) management.

(a) Gaps in Information

In comparison to the genetic resources in agriculture and horticulture, current knowledge of FGR in the country is grossly inadequate for a well-planned policy and management interventions in absence of comprehensive inventory on FGR species and quantitative information on their distribution, extent, abundance and threat status. FSI has started providing information on distribution of forest types at the national and state levels in the ISFR. Access to this GIS based information for varied users including scientists and researchers working in forestry institutions, NGOs and even private/ corporate entities engaged in tree improvement or agroforestry is a difficult and cumbersome process besides it involves exorbitant cost. Likewise, species distribution maps are vital, but rarely generated and available. There is a wide gap in the knowledge and skills required for developing insight on species/ population biology and dynamics including seeding and regeneration ecology, reproductive biology, and even response to silvicultural and management treatments, environmental and human induced disturbances. Precise information on reproductive biology (phenology, pollination/pollinators, mating system); seeding (periodicity/ season, seed type and morphology, quantity, dispersal, longevity) and regeneration ecology (seed germination, oil/protein content, dormancy, storage category - Orthodox, Recalcitrant, Intermediate); response to silvicultural and management treatments (thinning, felling, control burning, release from competing vegetation) are the foundation to run an efficient seed research facility/ center be it a seed gene bank or seed referral center. In case of majority FGRs, this vital information on varied aspects of seeds and germplasm is grossly lacking. Further, collation and exchange/ dissemination of such information amongst various stake holders of forestry sectors, particularly research and educational institutions, SFDs, farmers, tree growers, policy makers, etc. for assessing and utilizing such information for taking up new research programs, formulation of policies on sustainable utilization of FGR, etc. are very much wanting in the forestry research for the tree species. Environmental factors (fire, drought, cyclone, flood, pests, diseases, etc.), climate change and human induced disturbances (fragmentation or loss of forest, modification of surrounding of forest ecosystems, livestock grazing, lopping, forest fires, NTFP collection, translocation of germplasm from one place to another place and planting, etc.) also have profound impact on species and population biology.

So far, whatever FGR measurements are available have been made in an Ad.hoc manner in studies disjointed in time and space. The prerequisite for management of a complex and dynamic resource like FGR is a comprehensive documentation of the species, their populations and genetic diversity. Even as the total number of FGRs in the country is currently pegged at $\pm 8,733$ out of a total of 21,931 higher plant species (angiosperms and gymnosperms; see section 1.11.2) documented from the country till date, this documentation is believed to be far from complete. It could be appreciated from the fact that

through the report on 'Plant Discoveries' published annually by BSI, more and more plant species are being added to the country's flora. The problem is further compounded by the fact that the habitats of FGRs, especially the critical ecological niches, are experiencing an enhanced human induced pressure leading to further fragmentation and degradation, causing depletion in the populations of several important FGR, bringing them in the list of threatened species and making their conservation more challenging. Often, species of FGR with wider distribution but with fragmented and small populations give an illusion of plenty and of no immediate concern. Barring a few tree species of commercial importance and of very high socio-economic concern, knowledge on above stated information fields is wanting. Hence, any work on the FGR would have to be taken up ab initio. Further, there is very little work on conservation initiatives and germplasm improvement on the large diversity of species which are of much higher ecological significance.

(b) Gaps in Processes and Technology

The main criterion for including species in genetic resource conservation programs is their present and future possible value. The identification of genetic resources of priority is thus, in principle a cost benefit consideration (FAO, 2004). Ideally, cost benefit analyses need assessment of the values associated with a given species or population and the risk attached to the results of different management options. Considering the thousands of forestry species and their distribution over a vast area even in larger number of populations, the critical issues in gene conservation planning are: (i) how best to identify species to be included? and then (ii) how to select the populations to be conserved? In gene resource conservation, after species level decisions have been made, it is essential to know which population is to be prioritized for conservation. Thus, characterization on the basis of morphological traits, genetic variation and superiority on account of chemical and pathological attributes is required to generate reliable information for effective conservation of species and populations. Genetic variation is important for maintaining fitness and adaptability of species and of direct importance for people through the maintenance of goods and services. In past three decades or so, the tools and techniques for characterizing genetic diversity has evolved rapidly and further advancements in technology and understanding of the subject are taking place. In a country like India, a handful of FGR species have been attempted to be characterized on the basis of genetic parameters despite both the number of studies and the number of plant, animal and micro-organism species studied have increased significantly globally and nationally in the past decade or so. This situation is primarily on account of the fact that FGR includes a wide array of species occurring in the vast extent, exorbitant cost of the technology to generate huge baseline whole organism genomic information, limited dedicated institutions and highly skilled manpower, and rapid evolution of concepts, markers, indicators and emergence of accurate, advanced and sophisticated tools. Most studies conducted so far have been at the molecular level either using DNA markers or genomic technologies to characterize genetic resources. Molecular information is accumulating much faster than whole organism information with the consequence that little of the accumulating knowledge has direct application in management, improvement or conservation (FAO, 2014a). Tree and other FGR species in natural environment/ habitat coevolve wherein two or more species (plant, animal, microorganism) reciprocally effect each other's evolution. Important examples of coevolution in trees include interaction with pollinator and herbivores. The mutualistic relationship between trees and insects or vertebrate pollinators is of considerable interest. The plant-pollinator relationships are not always a strict one-on-one coevolutionary process, instead, there are many plant pollinator systems where diverse pollinator assemblages can lead to the maintenance of pollination services, plant reproduction and persistence, and relationships change over time and space (Alfaro et al., 2014). In other examples of coevolution in trees with herbivores, a number of constitutive and induced defense systems, both mechanical defenses (e.g., resin canals, sclereid cells and thorns) as well as chemical defenses (e.g., the production of toxic phenols and terpenoids) have evolved. Thus, as a result, plants produce a wide array of secondary metabolites and these products also have enormous social and economic values. In general, the genotypes producing higher quantities of such secondary metabolites are considered superior due to their strong defense mechanism as well as are of greater social and economic values. Varied populations of a tree species in its natural distribution range respond differently to pest attack and pathogens due to their inbuilt vigor. Populations showing little or no signs of infestation by pest and pathogens are being considered as superior and their germplasm have greater potential in tree improvement programs. A handful of FGR species have been characterized on the basis of chemical contents and infestation of fungal diseases. Chemical, pathological and genetic characterization of species is cumbersome, time consuming and expensive on account of occurrence of wide range of chemical compounds and fungal diseases within one species and huge genome size. These characterizations require multifarious tools/ techniques besides taxonomical know-how for fungal diseases. Collectively, these are the known constraints and gaps relevant to processes and technologies in FGR conservation.

(c) Gaps in Management

Harvesting of reproductive structures – flowers, fruits, and seeds directly reduce the effective size of the pool of reproductive parents and decline in genetic diversity in subsequent generations (FAO, 2001). In situations, where fruit and seed are harvested/ collected intensively, the genetic effects may be severe (e.g., *Phyllanthus emblica* fruits, *Madhuca longifolia* flowers). Selective commercial harvesting of fruits, nuts and oilseeds can also adversely affect the genetic composition of the tree species and populations being utilized. In such cases harvesting from mainly better fruit genotypes may result in a population

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dominated by trees of marginal economic value with much less value as a genetic resource. Presently, in the country, there is limited data on production and consumption of FGR based produce seriously affecting the planning for NTFPs and wood-based industries. A considerable quantity of fuelwood, fodder and other NTFPs is being either collected by people living in forest fringes and fringe forest areas as a part of their bonafide rights and concessions or even illegally. Most of the FGR species currently lack information about the extent of harvest/ collection and regeneration status besides generally inadequate data on their population biology, harvest pressures on them, etc.

1.11.14.2

Problem Statement

India's diverse forests are a rich repository of vast forest genetic resources (FGRs), which are unique as: (a) they represent a large and important subset of the documented higher plant diversity with most of these species being wild, and managed in natural habitats; (b) they are typically long lived, highly heterozygous group with high levels of intra-specific variations; (c) they perform multiple functions in the form of products and services, making selection of management options rather complex; (d) unlike in case of agricultural and horticultural species, conservation and management of FGR species is impacted by and is dependent upon a diversity of externalities, mainly environmental and biotic; and (e) the germplasm of FGR is either distributed in vast extent as scattered populations across various biogeographic regions in the country or are restricted to narrow distributional ranges making working on these a challenging and difficult task. Additionally, issues related to access, reliable and updated information as highlighted above is a serious constraint in planning for conservation of FGR. Involvement of varied stakeholders - sectors, agencies, beneficiaries, etc. and issues related to coordination and synergy among them make the task of FGR conservation a difficult one.

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1.11.14.3

Key Questions

In addition to above stated gaps and problems in conservation of FGR, following pertinent key questions come to the fore that needs to be answered for effective decision-making process and conservation of FGR:

- How to consolidate an inventory of FGR species specific to a site/ area/ region based on the
 existing information on forest floristics, consultative process, and field surveys so as to update
 species profile and prioritization of species for conservation action?
- What is the past and current distribution of wild populations of the prioritized and target species and specifically where are the remaining trees/ populations of the threatened species located, and what is their conservation status?
- How to consolidate the varied available information on the FGR as well as prioritized species from different agencies/ organizations and build upon the same to find gaps in understanding and carry forward the task of conserving and developing FGR?
- When and how to collect germplasm (seed, flower, tissue), process and store them for the
 development of protocols for short, medium and long term storage, characterization and
 appreciation of inter-specific variability and mechanisms of gene flow, genetic drift and genetic
 erosion so as to identify superior populations/ germplasm for conservation?
- How to plan specific conservation requirements, typically at the population level for single species and at the ecosystem level for group of species?
- How to arrest degradation of natural populations of the target species and improve status of its regeneration in the face of continuing and enhanced biotic pressure?
- How to develop a desired database for easy access of information and periodic updating based on monitoring?
- How to ensure coordination, cooperation, and synergy amongst varied stakeholders including multiple sectors and agencies for conservation of FGR?

1.12

National Program for Conservation and Development of FGR

The foregoing description amply reveals that the concept of FGR and their conservation is not new. A large number of organizations and agencies at the global, regional, national, state and local level have been directly or indirectly contributing on varied aspects of conservation of FGR. However, the publication of the SOW-FGR in 2014 and release of the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources by the FAO's Commission on Genetic Resources served as a blueprint document for world countries providing focused direction and pathways to deal with the complex and dynamic wealth of FGR. These two important documents at the global level triggered the requirement for focused attention on FGR in India.

1.12.1

Pilot Project on Conservation of FGR in Uttarakhand

As a follow up of the Global Plan of Action for FGR, in 2015, FRI on the advice of the MoEFCC and ICFRE prepared a 20-year (2016-2035) long term perspective plan entitled 'National Program for Conservation and Development of Forest Genetic Resources' incorporating details on Four Phases proposed, and also provided an implementation strategy for execution of a Pilot Project (2016-2021), and establishment of the 'Center of Excellence on Forest Genetic Resources (CoE-FGR) at FRI. The comprehensive Perspective Plan envisaging an overall budgetary outlay of Rs. 622.10 million was submitted to the Ministry. The MoEFCC, after due consideration and considerable deliberations on the perspective plan initially decided to sanction for implementation of a Pilot Project on FGR in the State of Uttarakhand and also for the establishment of CoE-FGR at FRI with a budgetary allocation of Rs. 86.12 million under the Ad.hoc CAMPA Fund over a period of five years. The first installment for the project was released in January, 2016 and the project activities commenced in April, 2016 after the engagement of project staff. The project was granted no-cost extension two times (one year and three months, respectively) in view of interruption of project activities on account of the Covid-19 pandemic and lockdown.

1.12.2

Phase I and Phase II Projects at the National Level

During the currency of the Pilot Project, FRI prepared a proposal for 10-year countrywide initiative entitled 'National Program for Conservation and Development of Forest Genetic Resources'. The 10-year Program envisaged two phases (Phase I and II) of 5-year each. The proposal for Phase I (2019-2023) was submitted to the MoEFCC for funding under the National CAMPA fund. The Governing body of National Authority (CAMPA) approved a major scheme entitled 'Strengthening Forestry Research for Ecological Sustainability and Productivity Enhancement' in November, 2019 and issued an OM dated 6 December, 2019 for funding. Subsequently, the MoEFCC endorsed the scheme in January, 2020. The approved scheme also included a prominent component on the Phase I of the National Program for Conservation and Development of FGR with a total budgetary outlay of Rs. 559.89 million. Out of this, Rs. 351.65 million and Rs. 168.24 million were allocated to two lead institutes viz., FRI and IFGTB, respectively for a duration of five years. As per the approved Phase I Project, FRI is expected to implement the project in collaboration with four other sister institutions viz., Himalayan Forest Research Institute (HFRI), Shimla; Arid Forest Research Institute (AFRI), Jodhpur; Rain Forest Research Institute (RFRI), Jorhat and Institute of Forest Productivity (IFP), Ranchi and cover as many as 18 States and 5 UTs of the country, while IFGTB is required to collaborate and coordinate efforts with three institutions viz., Tropical Forest Research Institute (TFRI), Jabalpur; Institute of Wood Science and Technology (IWST), Bengaluru; Institute of Forest Biodiversity (IFB), Hyderabad and made responsible to cover remaining 12 States and 3 UTs. By this way, nine institutions under the umbrella of ICFRE will cover all States/ UTs in the country for documentation, germplasm storage, characterization, and in situ and ex situ conservation of prioritized FGR, except the State of Uttarakhand which has already been covered in the Pilot Project. The Phase I Project commenced in the last quarter of the financial year 2019-2020.

Since above mentioned nine institutes under two lead organizations will not be able to cover all aspects of prioritized FGR spread over 30 States and 8 UTs, Phase II (2023-2028) with a budgetary outlay of Rs. 523.30 million has been proposed to the Japan International Cooperation Agency (JICA) for funding. In principle, JICA has agreed to support the Phase II Project. Final approval and details of funding are awaited

Conservation of Forest Genetic Resources



National Conservation and Development of Forest Genetic



Pilot Project

1.12.3

Components of the Pilot Project

The Pilot Project included primarily four Components as thrust areas. These included: (a) Documentation of FGR, (b) Storage of Germplasm of FGR, (c) Characterization of FGR, and (d) Conservation of FGR with multiple sub-components, and targeted specific activities (Fig. 1.21). The Project envisaged for the establishment of a specific Cell at FRI for each of these four components. The first Component on FGR Documentation included documentation of the diversity of FGR, population size, regeneration status, threat perception, and eco-distribution mapping. The second Component on Storage of Seed and Germplasm of FGR mainly included collection of seed and other germplasm, processing and development of protocols for their storage. The third Component on FGR Characterization aimed for assessment of genetic variability of the prioritized FGR species besides studies on fungal infestation and chemical contents in different plant parts of FGR. The fourth Component on Conservation of FGR planned and established forest gene banks and field gene banks for in situ and ex situ conservation of select priority species. Finally, varied outputs of four Components by different Cells were envisaged to contribute towards the development of database on FGR and making the CoE-FGR functional (Fig. 1.21). It was also stipulated that the Pilot Project will not only lay the foundation for initiation of subsequent phases but its outputs in the form of development of protocols, findings and outcomes will also immensely help in improving the scope and approach of project activities at the time of replication of similar efforts on FGR conservation in other States/ UTs of the country. The project successfully completed on 30 June, 2022 and as envisaged, the present document summarizes the project outputs and outcomes and highlight the overall impact.

Records

Herbarium

Status

Prioritization

Conservation of Forest Genetic Resources



Establishment Excellence on Resources (CoE-FGR)



Uttarakhand State

of FGR Storage of Germplasm of FGR Conservation of FGR · Seed Biology and Characterization of FGR • Viability and Vigour • Chemical Characterization · Seed Desiccation and Molecular Characterization Seed Storage • Disease (Fungal) Characterization · Pollen and In vitro

Documentation

of the Center of Excellence

• Field Gene Bank • Forest Gene Bank

Fig. 1.21 Four Components and Broad Activities of the Pilot Project on Conservation of FGR

Development of FGR Data Base and Establishment

Behaviour

Passport Data

Conservation

• Improving Availability and Access to Information, and Documentation Appraisal of Floristic and Taxonomic

 Field Exploration, Survey, and Inventory Digitization and Modernization of

Threat Perception and Species

Species Distribution and Mapping

Population Estimation and Regeneration

1.12.4

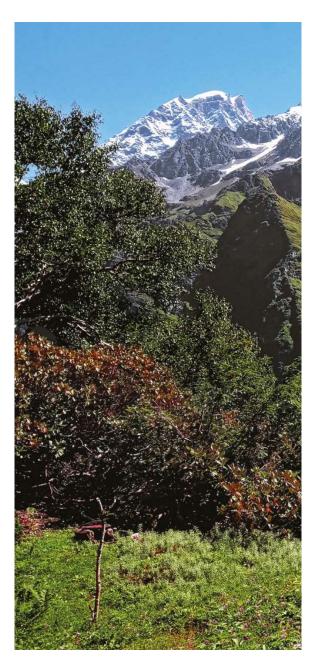
Functions of the Center of Excellence - FGR

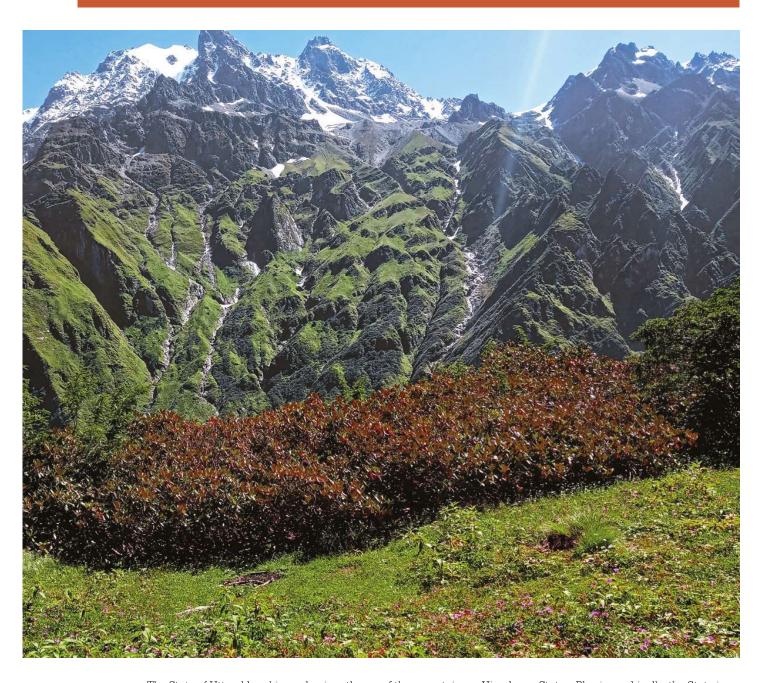
The goal of the proposed CoE-FGR is to serve as the 'Knowledge Center' by acting as One Stop Center for information and action on the FGR and shall perform the following major functions:

- Coordinate, steer and monitor all activities related to FGR documentation, evaluation, exchange, use and conservation.
- (ii) Consolidate the earlier works on the subject as carried out by different organizations and build upon the same to enhance understanding on the subject and carry forward the task of conserving and developing FGR.
- (iii) Serve as a national repository of all notified or released clones/ genotypes/ hybrids along with herbarium specimens and relevant information, besides being a national repository of original/parental lines.
- (iv) Guide restoration of the native landraces and varieties of FGR from areas that are frequently susceptible to natural disasters.
- Coordinate integrated conservation programs for threatened and economically important FGR including generation of biological and genetic information in collaboration with SFDs, ICFRE institutes and other national organizations/institutions.
- (vi) Create and service an Information and Research Network on FGR in the country. The MoEFCC has already made a beginning to create a Forest Genetic Resource Management Network (FGRMN) with IFGTB as the node.
- (vii) Create and manage computerized national database on FGR of the country.
- (viii) Bring out publications on the diversity, distribution, conservation and research status on FGR.
- (ix) Provide guidance and assist policy development; and implement FGR related work plans based on national, bilateral and international agreements.

Pilot Project -Demonstration State

The MoEFCC while sanctioning the Pilot Project decided to select the State of Uttarakhand as the 'Demonstration State' predominantly for four primary reasons. Firstly, the State is uniquely placed owing to its geographical, ecological, socioeconomical, and cultural diversity. Secondly, the FRI, a pioneer institution in the field of forestry in the Indian sub-continent, strongly backed up by professionals with multidisciplinary scientific and forest management background; infrastructure - reputed forestry-based Dehra Dun Herbarium (DD Herbarium), rich Library and Documentation Center as a repository of wealth of information, botanical garden, arboretum, bambusetum, well equipped laboratories, museums, etc.; and processes and innovative technologies relevant to conservation of forests and FGR is located in the capital of the State. Thirdly, from the perspective of forests, Uttarakhand is exceptionally rich as 71.05 per cent area of the State is RFA and represented by diverse forests covering total forest cover to the extent of 24,305.13 km² or 45.44 per cent of the State's area. These forests are repository of forest biodiversity including FGR and have well documented long history of management by the SFD and Van Panchayats. Fourthly, the State as well as the implementing agency i.e., FRI have privilege of resource inputs from various forestry institutions (FSI, IGNFA, WII, GBPIHESD, and CASFOS) and other reputed national scientific organizations (Northern Regional Center, BSI; IIRS; Indian Institute of Soil and Water Conservation; Wadia Institute of Himalayan Geology) besides benefit of universities and State level organizations relevant to forestry, wildlife, biodiversity and environment situated either at Dehra Dun itself or within the State.





The State of Uttarakhand is predominantly one of the mountainous Himalayan States. Physiographically, the State is represented by the Greater Himalayas, Lesser or Middle Himalayas, Outer Himalayas or Shiwalik Hills, and the Terai region. The altitude in the State ranges from about 250 m to 7,817 m. The State harbours a vast variety of forest vegetation owing to the varied geography, landforms, climatic conditions and cultural practices. Nearly, one-fifth of the total forest sub-types described in the country on basis of floristic, edaphic, and physiographic factors are found in the State. These forests offer a wide range of FGR species and include several endemic, rare and threatened species besides they are also rich repository of medicinal and aromatic plants. A large number of FGR species are being excessively/ over exploited and as a result face local extinction. In addition to the rich and diverse forest resources, the State also constitutes river basin of the National River Ganga and its principal tributaries like Bhagirathi, Alaknanda, Yamuna, Ram Ganga and Sharda. Prominent glaciers viz., Gangotri, Yamunotri, Khatling, Pindari, etc. and several small glaciers feed the river Ganga and play an important role in supporting all forms of life all along the river Ganga and its tributaries from its origin to sea. The diverse climatic conditions in the State are governed by its varied geography and ranges from sub-tropical climate in the south to the alpine climate in the upper reaches of the Greater Himalayas. The dependance of different social and ethnic groups, traditions, and culture have profound interrelationship with varied forests and they influence the distribution and diversity of FGR. Additionally, the State since its establishment in 2000 is witnessing a rapid all-round development, particularly multipurpose hydropower projects, linear infrastructureroads, rail, transmission lines, etc., urbanization and growing religious and nature-based tourism. These widespread developmental activities are aggressively opening up the forests in the mountains and exerting adverse pressure by way of fragmentation and loss of habitat and proliferation of invasive and alien species.

The Approach

The aforesaid introduction has clearly unfolded the fact that the conservation of FGR requires a comprehensive multi-sector. multi-scale, multi-discipline, and multistakeholder approach (Fig. 1.22). As stated above, the Pilot Project included four Components besides creation of database and establishment of CoE-FGR. A multipronged approach including the wider and extensive consultative process; field exploration, surveys, assessment and documentation; collection of seeds, processing, viability and vigour trials, and storage of priority species; pollen storage and tissue culture; characterization based on biochemical, genetic and pathological attributes: and in situ and ex situ conservation was adopted to fulfill the requirements of activities, tasks and actions entrusted under each of the Component. The broad-based multipronged approach is summarized and depicted in Fig. 1.23. The consultative process primarily aimed to prioritize FGR species for Uttarakhand and to firm up the methodology for field level explorations, surveys and assessments besides protocols for laboratory-based investigations/ studies. In March, 2022, FRI convened an Experience Sharing Workshop involving senior Forest Officers of Uttarakhand Forest Department. The workshop provided an opportunity to share findings on varied aspects of FGR by the multi-discipline project team of FRI and obtain feedback from the SFD. Project teams focusing on the assessment of current distribution of prioritized species and their status, and involved in collection of seeds and other germplasm visited different FDs and PAs. In addition, project team working on the aspects of in situ and ex situ conservation also devoted considerable time on varied field level activities in consultation with local forest officials. Teams specifically working on germplasm storage and characterization engaged themselves in laboratory-based investigations on prioritized FGR species. FRI signed an MoA with the ICAR- National Bureau of Plant Genetic Resources (NBPGR), New Delhi on 22 August 2017 so as to avail its well established facility of seed bank and cryopreservation. Hence, periodically team working on seed storage visited NBPGR for the purpose. Concurrently, an exercise to develop a database on FGR was also initiated. Details on specific methodologies adopted for each of the sub-component/ task are elaborated in corresponding subsequent chapters.

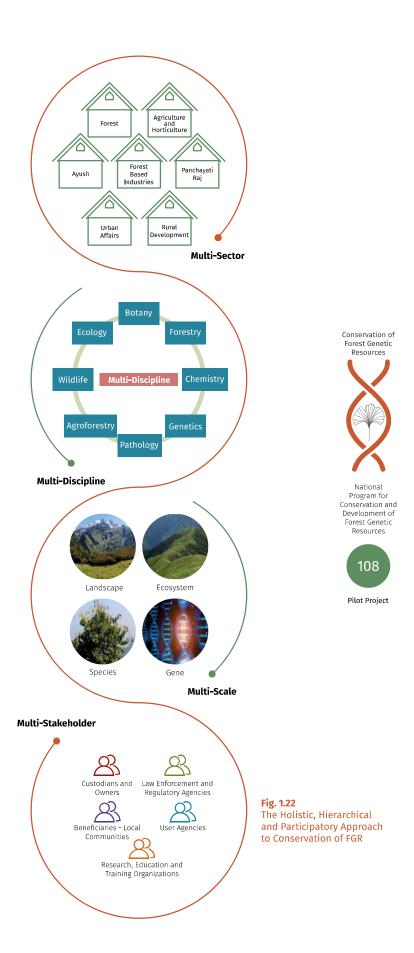


Fig. 1.23
The Multipronged
Componentwise Approach
of the Pilot
Project

CENTRE OF EXCELLENCE ON FOREST GENETIC RESOURCES (COE-FGR)

Conservation of Forest Genetic Resources



Establishment of Center of Excellence on Forest Genetic Resources (CoE-FGR)



Uttarakhand State

FGR Documentation and Knowledge Sharing



Field Exploration and Assessment

Digitization of Herbarium

Consultative Process

- Stakeholder Engagement
- Modernization and Digitization of DD Herbarium
- Species Profiling, Status, and Threat Perception
- Regeneration Status
- Eco-distribution Mapping

FGR Seed and Germplasm Storage



Field Surveys and Seed Collection

Pollen and In vitro Conservation

i Seed Processing, Viability Test and Storage



- Understanding of Seed Biology and Behaviour
- Seed Storage
- Tissue Culture and Alginate Encapsulation
- · Pollen Storage

FGR Conservation

Field Gene Banks

Forest Gene Banks

Circa situm

 Development of Nursery

Techniques

Banks

- Establishment of Field Gene Banks
- Identification and setting aside of Forest Gene

FGR Characterization

Pathological

Chemical

Molecular

 Population Structure and Variation

- Identification of Superior Populations
- Mechanism of Gene Flow and Genetic Barriers
 - Study of Fungal Diseases

The final output of the Pilot Project based on concurrent multi-discipline research and field-based studies is in the present book form. The book is divided into seven parts. The first part includes two chapters on the introduction of FGR and the unique characteristics of pilot demonstration State of Uttarakhand. The second part deals with the theme of documentation and improving access to information incorporating details on species profile, their distribution and regeneration status besides modernization of DD Herbarium and digitization. The third part covers three chapters on seed viability and vigour trials, and germplasm storage. The fourth part dwells upon vital aspect of characterization of prioritized FGR based on biochemical, molecular and pathological attributes. The fifth part elaborates on *in situ* and *ex situ* conservation measures adopted for select species. The sixth part provides a brief account of database developed on FGR. The last and seventh part attempts to provide a synthesis on the outputs, outcomes and impact of the Pilot Project while highlighting key messages, lessons learnt, recommendations and actionable points, and the way forward.

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National Program for Conservation and Development of Forest Genetic Resources



Pilot Project

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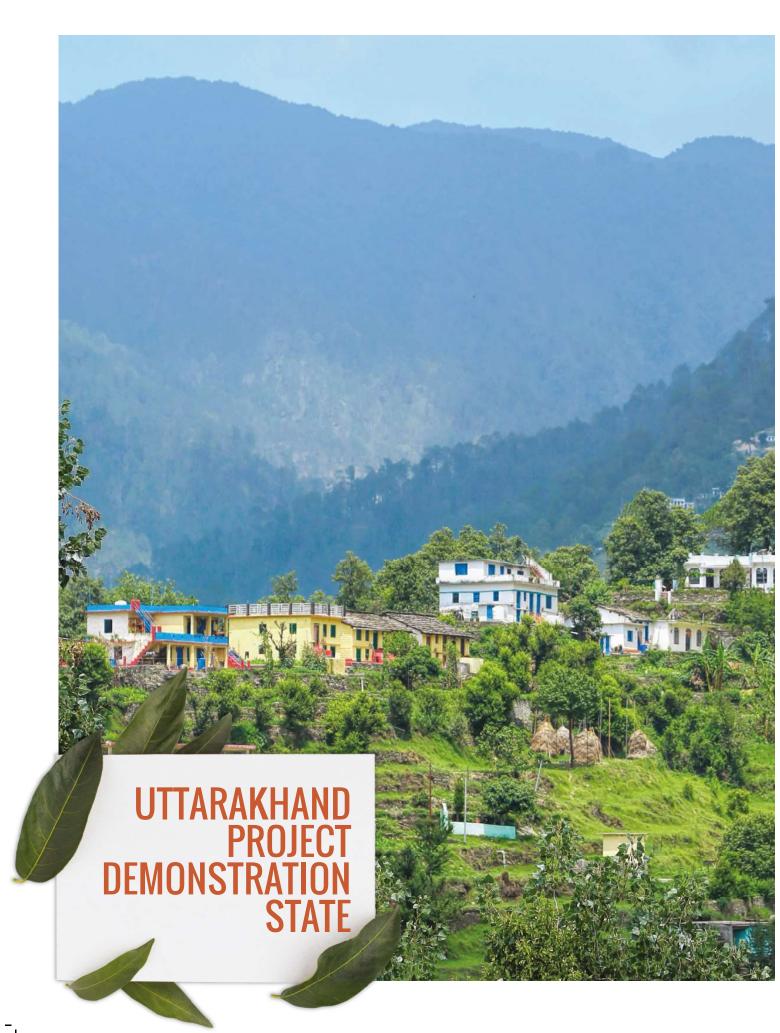
Conservation of Forest Genetic



Establishment of Center of Excellence on Forest Genetic Resources (CoE-FGR)



Uttarakhand State



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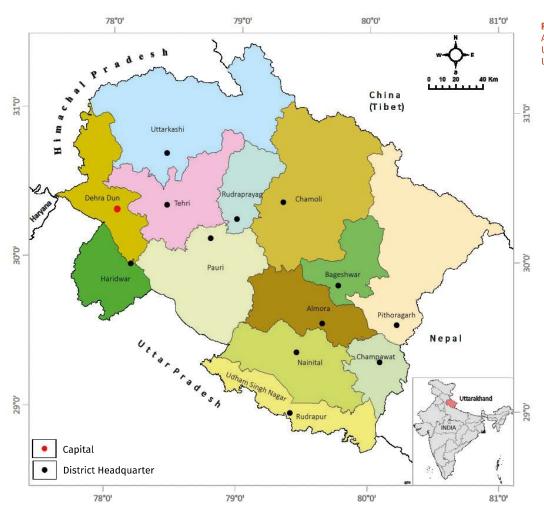


Fig. 2.1 Administration Units of Uttarakhand

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Uttarakhand was formed on the 9 November 2000 as the 27th State of India, when it was carved out of northern Uttar Pradesh. With a geographical area of 53,483 km², it is the nineteenth largest State of the Country in respect of area and twentieth largest in human population. It has been divided into two administrative regions- the western- Garhwal Mandal and the eastern- Kumaon Mandal, which are further divided into 13 districts. Dehra Dun is the largest city and the winter capital of the State (Fig. 2.1).

Geopolitically, Uttarakhand is also an important state as it shares international borders with China (Tibet) in north-west and Nepal in the east. There are four major river systems *viz.*, Ganga, Yamuna, Ramganga, and Sharda originating from the State along with their tributaries which are major source of water for drinking, irrigation and hydropower in the State as well as downstream regions of these river basins. The major wealth of the State is its forests with rich biodiversity. The State ranks sixth among the other states in terms of percentage of the RFA. Well known Himalayan peaks *viz.*, Nanda Devi (7,817 m, the second highest peak in India), Kamet (7,756 m) and Badrinath (7,138 m) and glaciers like Gangotri, Pindari, Milam, Khatling, etc. are present in Uttarakhand which not only regulate the climate in the region but also govern distribution of forests.

The chapter attempts to summarize the notable, unique, and interesting characteristics which identify Uttarakhand as a suitable state for the implementation of Pilot Project on conservation of FGR. The chapter outlines geographic, climatic, water and hydrological, forest, and biodiversity resources of the State besides socio-economics which directly or indirectly contribute towards the very existence and maintenance of FGR.



Geographical Diversity and Extent

An area of $46,035 \text{ km}^2$ or 86 per cent of geographical area of the State is mountainous. The state lies between latitude N $28^{\circ}43^{\circ}$ to $31^{\circ}28^{\circ}$ and longitude E $77^{\circ}34^{\circ}$ to $81^{\circ}03^{\circ}$ (FSI, 2021). The State is mainly represented by two biogeographic zones i.e., 2B West Himalaya and 7A Upper Gangetic Plains consisting of Garhwal and Kumaon regions. A small strip of 4A Semi-Arid Punjab Plains is present along the north western border of the State with Himachal Pradesh (Fig. 2.2).

The districts of Uttarkashi, Chamoli and Pithoragarh share international borders with China in Northwest, whereas the districts of Pithoragarh, Champawat and Udham Singh Nagar share international borders with Nepal in the East. Uttarkashi and Dehra Dun share inter-state boundaries with Himachal Pradesh in the north-west, while Dehra Dun, Haridwar, part of Nainital and Udham Singh Nagar touches the boundary of Uttar Pradesh in the south. Major portion of the State is mountainous and these mountains (Himalayas) are one of the youngest mountain systems of the world (40-50 million years in age compared to peninsular mountains of 1,500-2,500 million years old) and, hence, ecologically fragile and relatively much more susceptible to earthquakes and landslides.

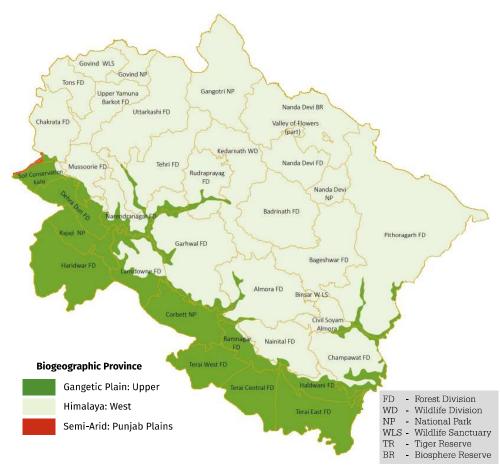
Fig. 2.2 Biogeographic Provinces of Uttarakhand



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2.1.1

Physiography

The Himalayan cross-section represented in Uttarakhand is physiographically classified into four zones, namely the Greater Himalayas, Middle or Lesser Himalaya, the Shiwalik Hills, and the Terai region. The northern snow-covered belt of mountains and glaciers known as the Himadri contains segments of the Zaskar and the Greater Himalayan Ranges, with elevations ranging roughly from 3,000 m to 7,000 m. Most of the major peaks are located in this zone. Adjacent to and south of the Greater Himalayas is a zone containing the Middle Himalayas, also known as the Himachal, with elevations ranging from 1,000 m to 3,000 m; the zone has two linear ranges *viz.*, Mussoorie and Nag Tibba. To the south of the Himachal is a stretch of the Shiwalik Range which abounds in coniferous and broadleaved forests and pastures. The southern edge of the Shiwalik Range merges with a narrow bed of gravel and alluvium known as the Bhabhar, which interfaces to the southeast with the marshy terrain known as the Terai which has higher water table. The Shiwaliks extend from altitudes of 300 m to 1,000 m. South of the Shiwaliks are found flat-floored depressions, known locally as dun valleys, such as the Dehra Dun (UAPCC, 2014).



2.1.2

Geology

Geology of the Himalayas is the product of ongoing convergence and collision of the Indian and Eurasian tectonic plates which is responsible for the physiography as well as fragility and disaster vulnerability of Uttarakhand. The young folded mountains of the Himalayan systems constitute the geology of Uttarakhand which comprises of three rock constituents. Precambrian rock forms the slopes of the region making it prone to erosion, weathering, and landslides. The region experiences recurrent geological and tectonic movements and lies in a zone of high seismicity with frequent earthquakes of different scales. Shiwaliks are highly important eco-region owing to its high endemic constitution and geological past as evidenced by the discovery of fossils of Amphibians, Reptiles, and Mammals. The era of Shiwalik ecosystem of rocks is called 'Age of Mammals'. It functions as the filtering corridor for migration of fauna and flora from highlands to lowlands and vice-versa and hence forms a doorway to enhanced biodiversity in the State, which in turn has been instrumental in the green and white revolutions, industrialization, and creation of livelihood opportunities. Important and high-grade minerals like limestone, magnesite, steatite, and tungsten, besides other minerals like asbestos, barytes, marble, copper, dolomite, graphite, gypsum, lead-zinc, silver, rock phosphate are found in the State (Indian Bureau of Mines, 2015).



Topography

The topography is predominantly mountainous with exception in the south where plains occur along the foothills. The altitude of the State varies from about 250 m to 7,817 m (Nanda Devi). Uttarakhand lies on the southern slope of the Himalayas. Roughly more than 50 per cent of the State's geographical area (29,001 km²), lies within the altitude range of 1,000 m to 4,000 m and 10,842 km² (20.27 per cent) lies at an altitude of more than 4,000 m (Table 2.1) (FSI, 2021). The various elevation classes are defined by varying climate and vegetation ranging from glaciers at the highest elevations to sub-tropical forests at the lower elevations. The highest elevations are covered with ice and bare rock. Below them, between 3,000 m and 5,000 m are the western Himalayan alpine scrub and meadows. The temperate western Himalayan sub-alpine conifer forests grow just below the tree line. At 3,000 m to 2,600 m elevation, they transit to the temperate western Himalayan broadleaved forests which lie in a belt of 2,600 to 1,500 m elevation. Below 1,500 m elevation lie the Himalayan sub-tropical pine forests. The upper Gangetic Plains moist deciduous forests and the drier Terai-Duar savanna and grasslands cover the lowlands along the Uttar Pradesh border in the Bhabhar belt. These lowland forests have been reduced to only a few scattered patches as most of it has been cleared for agriculture (FRI, 2016).

Sr. No.	Altitude Zone (m)	Area (km²)	Per Cent of State's GA	
1.	0-500	7,937	14.85	
2.	500-1,000	5,703	10.66	
3.	1,000-2,000	17,560	32.83	
4.	2,000-3,000	7,248	13.55	
5.	3,000-4,000	4,193	7.84	
6.	>4,000	10,842	20.27	
	Total	53,483	100	





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Table 2.1 Altitude-wise Distribution of Geographical Area of Uttarakhand

Source ISFR, 2021 (FSI, 2021) 2.1.4

Slope and Aspect

Uttarakhand being largely mountainous is comprised of a landscape with varying degrees of slopes. As much as 24.78 per cent of the state's geographical area has a slope of more than 30° and falls under very steep category, whereas another 26.17 per cent of the geographical area is constituted by slope classes varying from 20° to 30° . The slope class of 0° to 10° accounts for 25.27 per cent of the state's geographical area and 23.78 per cent is represented by 10° to 20° of slope (Table 2.2.)

Table 2.2 Altitude-wise Distribution of Geographical Area of Uttarakhand

Source India State of Forest Report, FSI, 2021

Sr. No.	Slope (°)	Area (km²)	Per cent of State's GA
1.	0-5	9,446	17.66
2.	5-10	4,069	7.61
3.	10-15	5,688	10.64
4.	15-20	7,028	13.14
5.	20-25	7,313	13.67
6.	25-30	6,683	12.50
7.	>30	13,256	24.78
	Total	53,483	100

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Aspect plays a notable role in the Himalayan State. The northern aspect is distinctly moist and harbours dense forests while southern aspect is predominantly drier and covered by grasses and sparse tree vegetation.

2.1.5

Soil

Soil is an important determinant of biodiversity and productivity and hence is considered as one of the most important natural resources. Information about soil type present in the State is thus pertinent to the cause of FGR conservation and will be contributory in charting out management strategies for forests, particularly FGR. Soil resources in Uttarakhand vary from the deep, alluvial and fertile soils of the Terai tract to the recently laid down alluvium of the Dun valley; the thin fragile soil of the Shiwalik hills; the black soils of the temperate zone; and the arid, bare soil of the inner dry valleys, all of which are susceptible to soil erosion. In the north, the soil ranges from gravel (debris from glaciers) to stiff clay. Brown forest soil, which is often shallow, gravelly, and rich in organic content is found farther in the south. In large portion of this region, the soil is mixed with fragments of parent rock occurring within a few centimetres, except in valleys or depression where they go up to two metre depth. The Bhabhar area is characterized by soils that are coarse-textured, sandy to gravelly, highly porous, and largely infertile. In the extreme southeastern part of the State, the Terai soils are mostly rich, clayey loams, mixed to varying degrees with fine sand and humus; they are well suited to the cultivation of rice and sugarcane (UAPCC, 2014).

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Climatic Conditions

Climatic conditions determine the vegetation type of an area and also results in development of ecotypes which in turn contribute towards variation in FGR of the area. The myriad climatic conditions of Uttarakhand varying from hot and moist subtropical climate in the southern part of the State to the cold alpine climate in the upper reaches of the Himalayan Mountains to warm and cool temperate climate persisting over the areas between southern and northern parts of the State define a wide diversity of FGR in the State. The climate at a particular place in the State is influenced by (a) altitude/elevation (b) latitude or location, and (c) slope and topography. The climate of Uttarakhand is distinguished in its two diverse divisions: the major hilly terrain and the smaller plains. Different climatic zones are identified as warm temperate (900-1,800 m), cool temperate (1,800-2,400 m), cold zone (2,400-3,000 m), alpine zone (3,000-4,000 m), glacier zone (4,000-4,800 m) and perpetually frozen zone (above 4,800 m) (FRI, 2016).

Temperature

Throughout the State, the temperature during winter ranges from sub-zero to 15°C. January is the coldest month, with daily high temperatures averaging below freezing in the north and near 21°C in the southeast. In the north, July is the warmest month, with temperatures typically rising from the about

 7° C to about 21° C daily. In the southeast, May is the warmest month, with daily temperatures normally reaching an average of 38° C to 27° C. With the onset of southwest monsoon, the maximum temperatures fall by about 3° C to 4° C, while the minimum temperatures are not affected significantly and remain similar to summer. During monsoon the temperature generally ranges from 15° C to 25° C (IMD, 2014).

Precipitation

The precipitation in the State occurs in the form of rain and snow. Snowfall occurs mostly in winter months and in the northern parts of the State, 3 m to 5 m of snowfall is common between December and March. January is the month with the heaviest snowfall. The rainfall in the State varies from place to place due to its rugged topography. The State has an average annual rainfall of 1,500 mm. Pithoragarh receives the highest rainfall which is around 2,000 mm and northern most part of the State lying in Uttarkashi receives the lowest rainfall which is around 700 mm. The eastern part of the Himalayas is subject to relatively heavier rainfall than the western part. Of the total amount of annual rainfall, about 78 per cent is received in the southwest monsoon season (June to September), 9 per cent is received in the winter season (December to February), 10 per cent in pre-monsoon season (March to May) and 3 per cent in post-monsoon season (October to November. July and August are the rainiest months and in these two months nearly 53 per cent of the annual rainfall is received. There are two rainfall minima observed in the State, one in April and other in November. After April, the rainfall gradually increases till June and thereafter sharply increases in July. It decreases rapidly after withdrawal of southwest monsoon from the last week of September. Precipitation during the premonsoon months is mostly associated with thunderstorms (IMD, 2014; IRI, 2018).

Droughts

Drought is a complex natural disaster that adversely affects human life and the ecosystem. Meteorological drought over an area or a place may be defined as a situation when the annual rainfall over the area or place is less than 75 per cent of the normal. It is classified as 'Moderate drought' if the rainfall deficit is between 25 per cent and 50 per cent and 'Severe drought' when it is more than 50 per cent. Areas where frequency of drought as defined above is more than 20 per cent of the years examined, such areas are classified as 'drought areas' and areas having drought condition for more than 40 per cent of the years under consideration represent 'chronically drought affected areas'. Nainital and Haridwar districts in the state experienced 10 and 6 years of drought, respectively out of 39 and 28 years of consideration during the period 1961-2010, satisfying the criteria for 'drought areas.' Occurrence of drought conditions in successive years is not frequent in the State (IMD, 2014).



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Hydrogeology

Uttarakhand State has a very diverse hydrogeological set-up which is divided into two regimes namely, Gangetic Alluvial Plains and Himalayan Mountain Belt. The description of these two hydrogeological units is given below:

Gangetic Alluvial Plains

The Gangetic Alluvial Plains is a vast expanse of alluvium of Tertiary and Quaternary age. Alluvium is a generalized term for detrital unconsolidated sediments comprising predominantly of clay, silt, sand and gravels formed on river beds, floodplains, alluvial fans, etc. This zone is very promising from the hydrogeological point of view having substantial water resource. This unit can be subdivided into three distinct hydrogeological regimes from south to north, *viz.*, Axial Belt, Terai, and Bhabhar (CGWB, 2021).

Himalayan Mountain Belt

This is a part of the Alpine-Himalayan Mountain Chain and constitutes a major part of the total geographical area of Uttarakhand. This zone is also known as Extra-Peninsular Region. The belt trends northwest – southeast with roughly parallel mountain ranges spanning across the state. This zone, being predominantly hilly, offers much less potential for large scale development of ground water. Ground water in the hilly region occurs mostly in fissures/ fractures and emerges as springs. This region can be further subdivided into five tectonic units from south to north. These units are Outer Himalaya, Lesser Himalaya, Central Himalaya, Tethyan Himalaya and Indus Suture Zone. However, the Indus Suture Zone does not fall within the geographical area of Uttarakhand State (CGWB, 2021).





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2.4

Water Resource and Watersheds

Water is the giver of life and a steady hydrological resource constitute the foundation of a healthy ecosystem and hence is imperative for proliferation and maintenance of FGR in their natural habitats. Uttarakhand is blessed in abundance with various glaciers and river basins, details of which are discussed below.

2.4.1

Glaciers

Mountain glaciers are not only an important component of global hydrological cycle but also have a significant impact on regional and local climate. The glaciers of the Uttarakhand are jointly fed by two major precipitation regimes: Indian Summer Monsoon during summer and mid-latitude westerlies during winter. Uttarakhand encompasses upper reaches of Ganga Basin and is home of 968 glaciers with a total glacier cover area of 2,378 km² (IRI, 2018). The glaciers of Uttarakhand extend for about 325 km from Kali Ganga in the east to Tons-Yamuna in the west. The entire State can be divided into four major basins in respect of glaciers namely (from east to west) Kaliganga, Alaknanda, Bhagirathi and Yamuna with a total number of glaciers of 271 (969 km²), 407 (1204 km²), 238 (755 km²) and 52 (205 km²), respectively. Chamoli is having maximum number of glaciers (32 per cent), followed by Pithoragarh (30.5 per cent), Uttarkashi (29 per cent), Bageshwar (5 per cent), Rudraprayag and Tehri-Garhwal (less than 2.5 per cent). The average size of glaciers in Uttarakhand is about 3.87 km (IRI, 2018). Some of the notable glaciers present in Uttarakhand are Gangotri the largest valley glacier (~30 km) in the Garhwal Himalayas; Yamunotri; Khatling; Pindari; Namik; Nanda Devi group of glaciers, etc. These glaciers support mighty perennial rivers such as the Ganga and Yamuna which in turn are the lifeline for the biodiversity of the respective river basins.



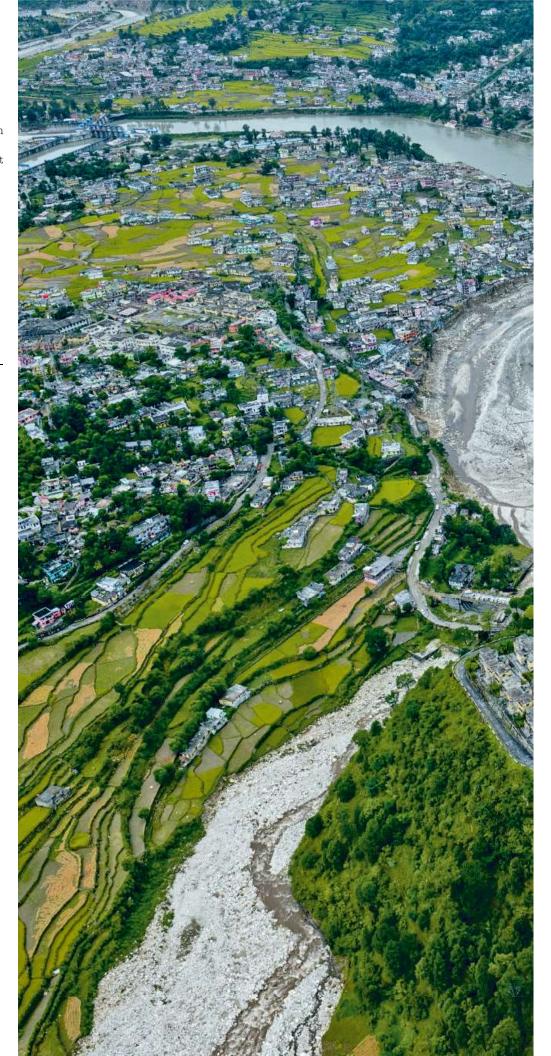
Rivers

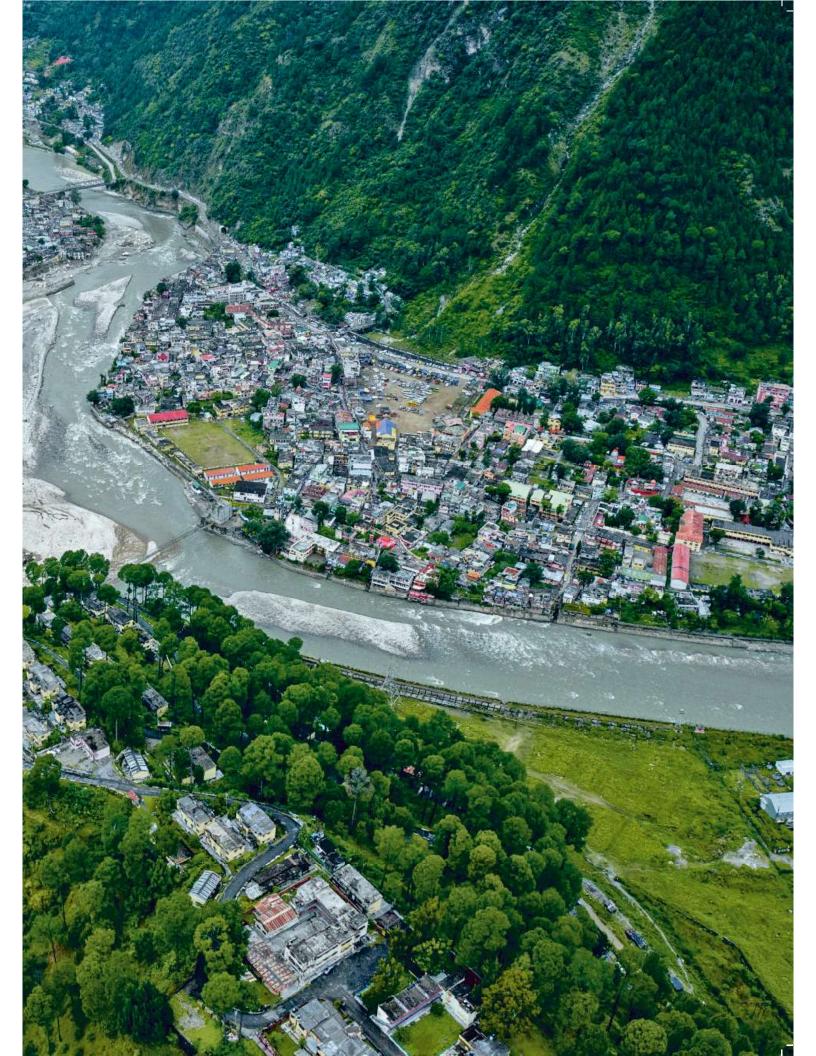
The State is primarily drained by the river Ganga and its tributaries which are largely fed by the glaciers and the forests. The State is often colloquially referred to as the devbhoomi (literally 'the land of the gods') due to the numerous temples and pilgrimage centres located largely along these rivers. The annual runoff varies from $972~\mathrm{Mm^3}$ in the Ramganga to a maximum of $5,342~\mathrm{Mm^3}$ in the Alaknanda. These rivers are the are the prime source of drinking water and irrigation, besides supporting the varied aquatic as well as terrestrial biodiversity of the State. Some of the important rivers of Uttarakhand described below (IMD, 2014):

2.4.3

Watersheds

Watershed is a hydrological unit of an area draining to a common outlet point. It is recognized as an ideal unit for planning and development of land, water and vegetation resource and strategizing management objectives. Watershed concept has been used extensively because of importance of water balance in the study of ecosystems and thereby plays an important role in conservation of FGR. The Land Survey Directorate (LSD) has divided the Uttarakhand into eight catchments, and 26 watersheds, which are subsequently divided into 110 Sub-Watersheds and 1,110 Micro-Watersheds (WMD, 2008).





Forest Resource

The State of Uttarakhand is blessed with the wealth of diverse forests. Forests are the storehouse of the biodiversity and help in regulating the climatic cycle. They play a pivotal role in the sustenance of the locals as they provide fodder, fuel, timber and leaf litter for farm yard manure, construction and industrial raw material. As per the Champion and Seth (1968) Classification of Forest Types, the forests in Uttarakhand belong to nine Forest Type Groups, which are further divided into 46 Forest Types. The Forest Types in Uttarakhand as per the Forest Types of India Atlas prepared by FSI in 2020 are summarized in Table 2.3.

The largest extent of forest found in the state is of 9/C1b Upper or Himalayan Chir Pine Forest which covers an area of 7,295.76 km², followed by 12/C1b Moru Oak Forest (*Quercus dilatata*), 3C/C2a Moist Shiwalik Sal Forest, 15/C3 (Alpine Pastures), 12/C2b West Himalayan Upper Oak/Fir Forest extending over 3,647.31 km², 3,402.49 km², 1,514.99 km², and 1,454.52 km², respectively.

Sr. No. **Forest Types** Area in **Per Cent Per Cent** Change in 2021 (km²) of the total of the Total Per Cent Mapped **Forest Cover** from 2019 Area in in 2019 to 2021 2021 3C/C2a Moist Shiwalik Sal Forest 3,402.49 12.84 14.05 -1.21 1. 2. 3C/C2b (1) Bhabar-dun Sal Forest 0.95 251.06 3. 3C/C2c Moist Terai Sal Forest 401.60 1.51 1.56 -0.05 4. 3C/C2d (i) Western Light Alluvium 165.52 0.62 0.00 0.62 Plains Sal 3C/C3a West Gangetic Moist Mixed 3.99 -0.05 5. 1.055.48 4.04 Deciduous Forest 6. 4C/FS2 Submontane Hill-Valley 0.76 0.00 0.00 0.00 Swamp Forest 7. 0.15 5B/C1a Dry Shiwalik Sal Forest 455.92 1.72 1.57 8. 5B/C1b Dry Plains Sal Forest 8.31 0.03 0.04 -0.01 9. 5B/C2 Northern Dry Mixed 903.31 3.41 3.59 -0.18 Deciduous Forest 10. 5/DS1 Dry Deciduous Scrub 39.02 0.15 0.16 -0.01 0.95 11. 5/1S2 Khair-Sissu Forest 252.36 0.97 -0.02 12. 9/C1a Lower or Shiwalik Chir 0.16 -0.02 43.15 0.18 Pine Forest 9/C1b Upper or Himalayan 13. 7,295.76 27.52 27.97 -0.45 Chir Pine Forest 14. 9/DS1 Himalayan Sub-tropical 379.26 1.43 1.61 -0.18 15. 9/DS2 Sub-tropical Euphorbia 28.37 0.11 0.11 0.00 Scrub 12/C1a Ban Oak Forest 16. 3,647.31 13.75 13.86 -0.11 (Quercus incana) 17. 12/C1b Moru Oak Forest 122.71 0.46 0.47 -0.01 (Quercus dilatata) -0.06 18. 12/C1c Moist Deodar Forest 395.23 1.49 1.55 (Cedrus deodara) 19. 12/C1d Western Mixed Coniferous 1.340.10 5.05 5.01 0.04 Forest (Spruce, Blue Pine, Silver Fir) 0.76 20. 12/C1e Moist Temperate 202.07 0.79 -0.03 Deciduous Forest 21. 12/C1f Low-Level Blue Pine Forest 27.66 0.10 0.09 0.01 (Pinus wallichiana) 22. 12/C1/DS1 Oak Scrub 29.93 0.11 0.14 -0.03 23. 12/C1/DS2 Himalayan Temperate 14.09 0.05 0.06 -0.01 Secondary Scrub

Table 2.3Forest Types in Uttarakhand

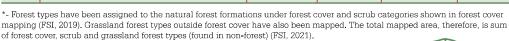
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Sr. No. **Per Cent** Change in **Forest Types** Area in **Per Cent** 2021 (km²) of the Total of the Total **Per Cent** Mapped **Forest Cover** from 2019 to 2021 Area' in in 2019 2021 24. 12/C2a Kharsu Oak Forest 832.04 3.14 3.08 0.06 (Quercus semecarpifolia) 25. 12/C2b West Himalayan Upper 1,454.52 5.48 5.49 -0.01 Oak/Fir Forest -0.03 26. 12/C2c (Moist Temperate 201.57 0.76 0.79 Deciduous Forest) 27. 0.03 0.03 0.00 12/1S1 Alder Forest 8.13 28. 12/2S1 Low Level Blue Pine Forest 22.49 0.08 0.09 -0.01 29. 194.73 0.73 0.73 0.00 13/C2b Dry Deodar Forest (Cedrus deodara) 0.00 30. 4.28 0.02 0.02 13/C5 West Himalayan Dry Juniper Forest (Juniperus macropoda) 0.00 31. 13/1S1 Hippophae / Myricaria Scrub 67.66 0.26 0.26 32. 14/C1a West Himalayan Sub-Alpine 184.29 0.69 0.71 -0.02 Fir Forest 33. -0.02 14/C1b West Himalayan Sub-Alpine 542.11 2.04 2.06 Birch/Fir Forest 34. 0.00 14/1S1 Hippophae / Myricaria Brakes 20.23 0.08 0.08 14/1S2 Deciduous Sub-Alpine Scrub 42.77 0.00 35. 0.16 0.16 36. 15/C1 Birch/Rhododendron Scrub 117.18 0.44 0.45 -0.01 Forest 37. 15/E1 Dwarf Rhododendron Scrub 12.95 0.05 0.06 -0.01 38. 16/C1 Dry Alpine Scrub 2.78 0.01 0.01 0.00 39. 16/E1 Dwarf Juniper Scrub 29.92 0.11 0.12 -0.01 24,199.12 91.24 92.58 -1.34 **Sub Total** 0.85 0.99 40. TOF/Plantation 487.09 1.84 24,686.21 **Total (Forest Cover & Scrub) Grassland Forest Types (Outside Forest Cover)** 0.01 41. 0.03 0.02 3C/DS1 Moist Sal Savannah 8.75 42. 3/1S1n Low Alluvial Savannah 3.30 0.01 Woodland (Salmalia-Albizzia) 43. 12.38 0.05 0.03 0.02 12/DS2 Himalayan Temperate Parkland 44. 12/DS3 Himalayan Temperate 84.66 0.32 0.16 0.16 Pastures 45. 14/DS1 Sub-Alpine Pastures 212.05 0.80 0.82 -0.02 46. 15/C3 (Alpine Pastures) 1,514.99 5.71 5.54 0.17 Sub Total 1,836.13 6.92 6.57 0.35 **Grand Total** 26,522.34 100.00 100.00



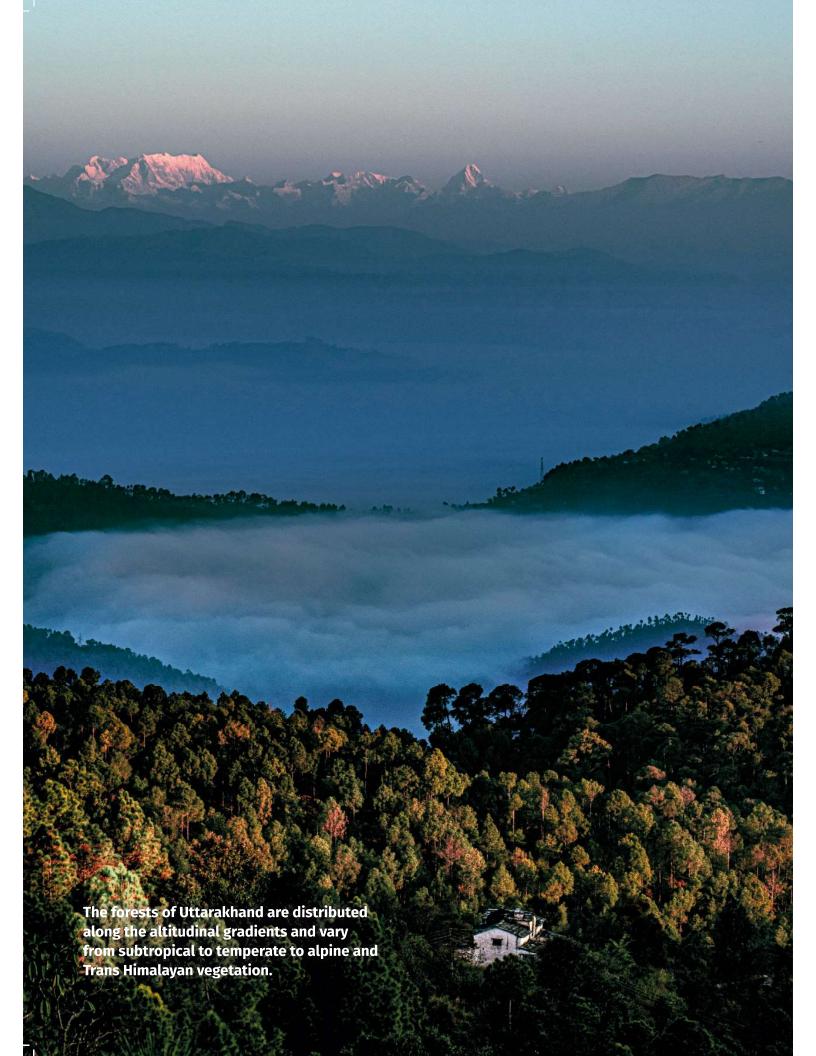
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Total Recorded Forest Area (RFA) of the State was 38,000 km² in year 2021 (Reserved Forests- 26,547 km², Protected Forest- 9,855 km² and Unclassed Forest- 1,568 km²), which is 71.05 per cent of the total geographical area of the State. According to the biennial survey conducted by the FSI, most recent results of which were summarized in the ISFR 2021, the total Forest Cover in the state is 24,305.13 km² which is 45.44 per cent of the State's total geographical area. Of the total Forest Cover 5,055.01 km² (9.45 per cent) is Very Dense Forest (VDF), 12,768.05 km² (23.87 per cent) is Moderately Dense Forest (MDF), and 6,482.07 km² (12.12 per cent) is Open Forest (OF) (Table-2.4). Also, 0.73 per cent (392.37) of the State's total geographical area is classified as Scrub. There is an increase of 2.09 per cent in the total Forest Cover of the state since the previous survey in 2019. The VDF and OP have increased by 8 km² and 31 km², respectively but the MDF has decreased by 37 km² in the State (FSI, 2021).

Table 2.4
Forest Cover
Statistics of
India and
Uttarakhand

Source Source: ISFR 2021 (FSI, 2021)

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Sr. No.	Forest Statistics	India	Uttarakhand	Per Cent in Uttarakhand w.r.t. to India
1.	Geographical Area (km²)	32,87,469	53,483	1.63
2.	Recorded Forest Area (km²)	7,75,288	38,000	4.90
3.	Very Dense Forest (km²)	99,779	5,055	5.07
4.	Moderately Dense Forest (km²)	3,06,890	12,768	4.16
5.	Open Forest (km²)	3,07,120	6,482	2.11
6.	Forest Cover (km²)	7,13,789	24,305	3.41
7.	Per cent of Forest Cover w.r.t. to Geographical Area	21.71	45.44	-
8.	Scrub (km²)	46,539	392	0.84
9.	Forest Cover in 2019 (km²)	7,12,249	24,303	3.41
10.	Change w.r.t. 2019 Assessment	1,540	2	0.13

It is interesting to note that of the total Forest Cover of the country, 3.41 per cent is present in Uttarakhand, and a significant portion of the country's VDF and MDF i.e., 5.07 per cent and 4.16 per cent, respectively is present in the State (Table 2.6).

On examining the decadal pattern of change in Forest Cover, it was observed that the Forest Cover increased by $558~\mathrm{km^2}$ from 2001 to 2011 and thereafter decreased by $191~\mathrm{km^2}$ from 2011 to 2021. Overall, the Forest Cover of the State has increased by $367~\mathrm{km^2}$ over a period of two decades.

Amongst the 13 districts of the State, Nainital has the highest percentage (71.62 per cent) of Forest Cover with respect to its total geographical area, whereas Udham Singh Nagar has the lowest (16.84 per cent). Nainital also has the highest area under the VDF class as compared to other districts, followed by Dehra Dun and Uttarkashi. The area under MDF class is maximum in Pauri Garhwal, followed by Nainital and Uttarkashi. The Open Forest area is highest in Pauri Garhwal. Districts of Udham Singh Nagar, Tehri Garhwal, Champawat, Haridwar, and Bageshwar have shown decline in Forest Cover since the 2019 assessment. The Forest Cover in Nainital and Dehra Dun has increased by 2.93 km² and 2.89 km², respectively.

As per FSI (2021) the Tree Cover in Uttarakhand is $1,001 \text{ km}^2$ which is higher by 160 km^2 from 2019 s assessment. The total extent of Forest Cover and Tree Cover in Uttarakhand is $25,306 \text{ km}^2$, which constitutes 47.31 per cent of the total geographical area of the State. The total extent of Tree Outside Forest (TOF) in the State has increased by 167 km^2 and now stands at $8,521 \text{ km}^2$.

The distribution of Forest Cover of the State across various altitudinal zones reveals that 65.11 per cent of the total Forest Cover exists in the 1000 m to 3000 m zone, which includes more than $3,000 \text{ km}^2$ of the total $5,055 \text{ km}^2$ of Very Dense Forest Cover of the State (Table 2.5).

Table 2.5Altitude-wise
Forest Cover
in
Uttarakhand

Source ISFR (FSI, 2021)

Sr. No	Altitude Zone (m)	Geographical Area (km²)	VDF (km²)	MDF (km²)	OF (km²)	Total (km²)	Scrub (km²)
1.	0-500	7,937	627	1,627	626	2,880	13
2.	500-1000	5,703	1,198	1,858	902	3,958	103
3.	1000-2000	17,560	1,573	5,157	3,319	10,049	241
4.	2000-3000	7,248	1,552	3,092	1,134	5,778	21
5.	3000-4000	4,193	105	1,033	496	1,634	13
6.	>4000	10,842	0	1	5	6	1
	Total	53,483	5,055	12,768	6,482	24,305	392

Majority of the State's geographical area falls under $>30^\circ$ slope category and houses 5,826 km² (23.97 per cent) of the total Forest Cover of the State. Highest extent of VDF, MDF, OF, and Scrub also falls under $>30^\circ$ slope category. The slope class of 20° to 25° contains 7.16 per cent and 15° to 20° contains 6.70 per cent of the total Forest Cover of the State.

The total estimated growing stock in both the RFA (401.01 m cum) and the TOF (18.40 m cum) has decreased by 5.07 m cum and 1.03 m cum, respectively as compared to the assessment of 2019 (FSI, 2021).

The total Carbon stock in the forests of Uttarakhand is $3,78,159 \times 10^3$ tonnes, which is higher by 7,247 tonnes from 2019. The total Bamboo bearing area has decreased from $1,489 \text{ km}^2$ in 2019 to $1,201 \text{ km}^2$ in 2021. The number of bamboo culms has also decreased from 384 in 2019 to 301 in 2021. Although, the total equivalent green weight of bamboos has increased significantly from $1,390 \times 10^3$ tonnes in 2019 to $2,839 \times 10^3$ tonnes in 2021 (FSI, 2021).

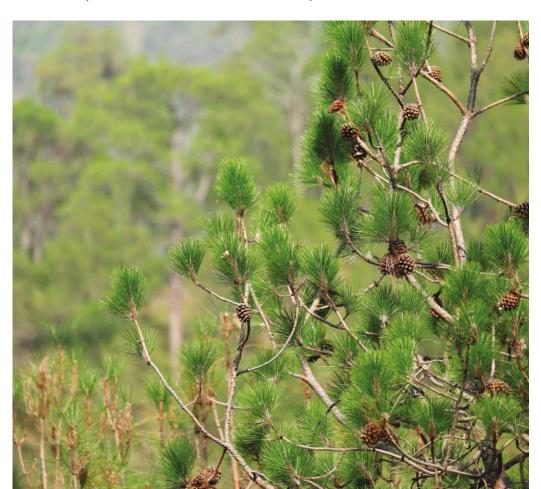
Of the total forest cover of the state, 49.21 km^2 (0.20 per cent) is extremely fire prone while 757.92 km² (3.12 per cent) is very highly fire prone, $4,070.09 \text{ km}^2$ (16.75 per cent) is highly fire prone, and $5,887.70 \text{ km}^2$ (24.22 per cent) is moderately fire prone. Overall, 44.29 per cent of the total Forest Cover is fire prone and 55.71 per cent is less fire prone (FSI, 2021).

On the basis of Forest inventory data, the FSI enlists five dominant tree species in the Recorded Forest Area of the state with their diameter class. These species are *Pinus roxburghii*, *Quercus leucotrichophora*, *Rhododendron arboreum*, *Shorea robusta*, and *Q. semecarpifolia*. In the TOF category, *Grewia oppositifolia*, *Q. leucotrichophora*, *P. roxburghii*, *Mangifera indica*, and *Ficus* spp. are dominant in the rural areas whereas, in TOF of urban areas, *Q. leucotrichophora*, *Mangifera indica*, *Cedrus deodara*, *Cupressus spp.*, *P. roxburghii* are reported to be dominant (FSI, 2021).

2.5.1

Forest Administration Structure

Uttarakhand has an advantageous position when it comes to forest management due to a well devised and effective forest administration system in place. The Forest area of Uttarakhand is divided into 17 Circles, which is further sub divided into 44 Forest Divisions containing a total of 284 Forest Ranges (Fig. 2.3) (Table 2.6). Many important and well managed National Parks, Wildlife Sanctuaries, and Conservation Reserves are also present in the State (Table 2.6). In addition to this, 4,768.70 km² of forest area is Civil Soyam Forest and comes under the Revenue Department.



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Table 2.6 Distribution of Forest Area Under Uttarakhand Forest

Source Compiled from Uttarakhand Forest Statistics 2016-17; ISFR 2017 (FSI, 2017); Uttarakhand CAMPA -**Annual Report** 2019-20 (Uttarakhand CAMPA, 2020).

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Name of the Circle/ Administrative	Name of Division	Reserved Forest (km²)	Protected Forest (km²)	Unclassified & Vested Forest (km²)	Total Forest Area (km²)
Control Garhwal Zone					
Shiwalik	Dehra Dun FD	493.71	0.00	11.12	504.82
Billwalik	Lansdowne FD	415.52	17.76	0.15	433.43
	Soil Conservation FD, Kalsi	233.18	0.00	0.03	233.21
	Haridwar FD	330.38	21.23	39.13	390.74
	Sub-Total	1,472.79	38.99	50.43	15.62
Bhagirathi	Tehri FD	1,432.69	0.00	0.00	1,432.69
	Uttarkashi FD	2,243.71	0.10	0.00	2,243.81
	Narendranagar FD	621.08	0.00	0.00	621.08
	Sub-Total	4,297.47	0.10	0.00	4,297.57
Yamuna	Mussoorie FD	390.72	0.00	0.11	390.83
	Tons FD	622.09	0.00	0.00	622.09
	Upper Yamuna FD	743.95	0.00	0.03	743.97
	Chakrata FD	361.68	42.88	0.14	404.71
	Sub-Total	2,118.44	42.88	0.27	2,161.60
Garhwal	Garhwal FD	701.62	0.00	0.00	701.62
	Rudraprayag FD	598.67	0.00	0.00	598.67
	Badrinath FD	1,346.45	0.00	0.00	1,346.45
	Sub-Total	2,646.74	0.00	0.00	2,646.74
	Total Garhwal Zone	10,535.44	81.97	50.70.	10,668.11
Kumaon Zone					
North Kumaon	Bageshwar FD	662.36	0.00	1.08	663.44
	Almora FD	610.82	0.00	1.20	612.02
	Civil Soyam Almora FD	111.08 755.83	0.00	0.00 1,444.51	111.08
	Pithoragarh FD Champawat FD	659.80	0.00	1,444.51	2,200.34 660.97
	Sub-Total	2,799.89	0.00	1,447.95	4,247.85
South Kumaon	Nainital FD	596.08	507.07	0.00	601.15
Western	Haldwani FD	595.79	0.00	0.00	595.79
Circle	Terai East FD	818.47	5.83	0.00	824.30
	Terai West FD	344.61	2.24	1.21	348.07
	Terai Central FD	404.40	0.57	0.00	404.97
	Ramnagar FD	484.42	2.94	0.01	487.37
	Sub-Total	2,647.70	11.57	1.22	2,660.49
	Total Kumaon Zone	6,043.67	16.64	1,449.18	7,509.49
Wildlife Zone					
PCCF, Wildlife, Uttarakhand	Gangotri National Park Govind National Park & Wildlife Sanctuary	2,390.02 957.97	0.00 0.00	0.00 0.00	2,390.02 957.97
Director, Corbett Tiger Reserve	Kalagarh Tiger Reserve Division	626.69	0.00	0.04	626.73
	Corbett Tiger Reserve	661.62	0.00	0.00	661.62
Director, Rajaji Tiger Reserve	Rajaji Tiger Reserve	851.63	0.00	0.00	851.63

Name of the Circle/ Administrative Control	Name of Division	Reserved Forest (km²)	Protected Forest (km²)	Unclassified & Vested Forest (km²)	Total Forest Area (km²)
Director Nanda Devi Biosphere Reserve	Nanda Devi National Park	799.08	0.00	0.00	799.09
	Kedarnath Wildlife Division	1,351.45	0.00	0.00	1,351.45
DFO, Soil Conservation Forest Division, Almora	Binsar Wildlife Sanctuary	47.07	0.00	0.00	47.07
Total Wildlife Z	one	7,685.53	0.00	0.04	7,685.58
Grand Total of Forest Area in Uttarakhand		24,264.64	98.61	1,499.92	25,863.18



Fig. 2.3 Forest Divisions of Uttarakhand





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Uttarakhand has two important Tiger Reserves (TR) $\emph{viz.}$, Corbett TR and Rajaji TR, with a total of 231 and 38 tigers, respectively. Corbett has a tiger density of 14 tigers per 100 km² and Rajaji has 8 tigers per 100 km² (FSI, 2021).

The State also has the recently identified Shivalik Elephant Reserve which was notified in the year 2002, with an area of 6,404 $\rm km^2$ (Project Elephant Division, MoEFCC).

The second biosphere reserve of the country Nanda Devi Biosphere Reserve (NDBR), is spread across three districts of Uttarakhand *viz.*, Chamoli, Pithoragarh and Bageshwar and covers an area of over 6,407.03 km² (Rawat and Negi, 2021) and is recognized as a UNESCO World Heritage Site.



2.5.2

Van Panchayats

The State of Uttarakhand occupies a special place in community driven management of natural forest resources because of its Van Panchayat system. The Van Panchayat system was born out of conflicts and compromises that followed the settlement and reservation of forests in the hills at the turn of the 19th century in the summer of 1921. Van Panchayats or Forest Councils have been incorporated under Section 28(2) of the Indian Forest Act, 1927. Their objectives are to protect and develop forests and distribute their produce among stakeholders in an equitable manner. At present, there are 12,168 Van Panchayats in the State, which manage an area of 7,325.89 km² of forest. The maximum number of Van Panchayats is in Pauri Garhwal district followed by Almora, while maximum area under Van Panchayat out of the total area under Van Panchayat is in Chamoli district.

2.5.3

Sacred Groves

Sacred groves are undisturbed or preserved patches of vegetation or forested area protected communally with spiritual sentiments and undertone. These groves are mostly associated with temples and are also culturally important. They symbolize the religious and ecological ethos of rural indigenous communities. This basic dependence on the existence of forests for human survival was the reason for the worship of trees in almost all human societies. In each region in India, special attention was devoted to the growth of village forests that contained multi-purpose tree species providing fuel, fodder, fruits, fiber, green manure etc. The ecological role of forests in soil and water conservation was widely recognized, and the social control of felling of trees in ecologically sensitive areas such as riverbanks was strictly enforced. This principle of civilization became the foundation of forest conservation as a social ethic through the millennia (Shiva, 1991). Accordingly, Hughes and Chandran (1997), define sacred groves as 'segments of landscape containing vegetation, life forms and geographical features, delimited and protected by human societies under the belief that to keep them in a relatively undisturbed state is expression of an important relationship of humans with the divine or with nature.'

It is effectively an indigenous way of protecting trees and forests.

This veneration results in protection of different species of trees and animals that are economically important or threatened in other areas are preserved and constitute a genetic reservoir which will serve as insurance against extinction of these species (Anthwal *et al.*, 2010). For example, Dodital and Devariya Tal, two lakes in Uttarkashi and Rudraprayag district of Uttarakhand, are considered sacred, so fishing is completely restricted (Colding and Folke, 1997). Therefore, the religious belief serves as an instrument of protection of rare and threatened species. Religious beliefs, tradition, and culture are the products of logical internalization of human experience and learning. For example, in Garhwal Himalaya, *Ficus religiosa* is considered to be sacred. There are many instances where communities control the excess use of resource by confining the approach to resources and enforcing compliance through religious belief, rituals, and social convention which at last result in providing temporal and spatial refuge to biodiversity in such communities (Singh *et. al.*, 2017).

Sacred groves are locally known by various names such as Deo Bhumi and Bugyal (sacred alpine meadows). These groves are dedicated to primeval deities and venerated in their names, some of these deities of Uttarakhand are *Chandrabadni Devi, Hariyali Devi, Pravasi Pavasu Devata, Devrada*, etc. The sacred groves serve as a gene pool for the diverse assemblage of flora and fauna that inhabit the forests and thereby a repository of FGR. Various traditional practices sustained by the local communities play an important role in preserving threatened plant and animal species in the region. The sacred groves are generally observed to be a treasury of medicinal and aromatic plants. The most commonly found trees in the groves include *Chaerophyllum bulbosum* (Turnip-root chervil), *Cedrus deodara* (Himalayan cedar), *Selaginella bryopteris* (Sanjeevani), *Berberis aristata* (Indian Burberry), *Pyracantha crenulata* (Himalayan firethorn), *Valeriana jatamansi* (Sugandhbala or Tagar), etc. (Singh et al., 2019).

2.5.4

Biodiversity Management Committees (BMCs)

Under Section 41(1) of the Biological Diversity Act, 2002, every local body in the State shall constitute a Biodiversity Management Committee within its area of jurisdiction for the purpose of promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties & cultivars, domesticated stocks and breeds of animals and micro-organisms and chronicling of knowledge relating to biological diversity. Under section 63 of the Biological Diversity Act, 2002, Uttarakhand Biological Diversity Rules, 2015 have been

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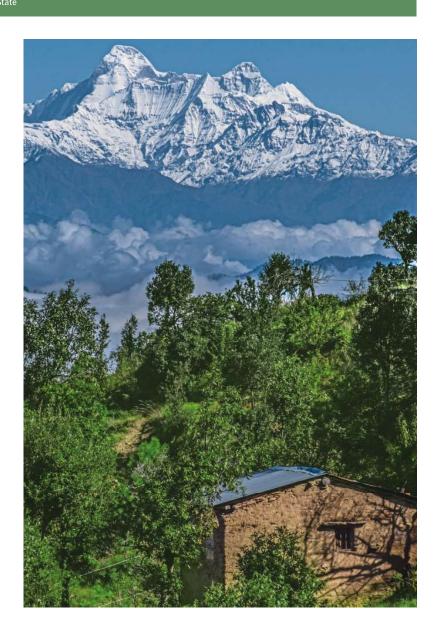


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2.5.5

Joint Forest Management Committees (JFMCs)

The notion of Joint Forest Management (JFM) was formulated as a part of the National Forest Policy of 1988 to put together an approach of cooperative forest protection and management by the SFDs and the local forest dwelling/ forest fringe communities and share the costs and benefits from the forests amongst them. The communities are required to organize themselves into a JFM Committee to protect and manage surrounding forests by means of by-laws and micro plans. JFM was initiated in Uttarakhand in 1992 when it was a part of Uttar Pradesh State. There are about 12,738 JFM Committees managing 5,642.21 km² (14.85 per cent) of forest area in Uttarakhand by involving 6,29,000 families (FRI, 2011). Under JFM, employees of SFD and office bearer of village assembly work together to conserve forests. Besides, Soil Conservation Department also conserve forests mainly in the degraded land (Sati and Bandooni, 2018).



2.6

Plant Diversity of Uttarakhand

The vast floristic diversity further marks the uniqueness of Uttarakhand in terms of richness of FGRs. By virtue of its extensive geographical stretch, varied terrain and climate the State has a total of 7,059 species including *viz.*, angiosperms (5,296), gymnosperms (35), pteridophytes (365), bryophyets (478), algae (346), and lichens (539) (Table 2.7) (Kumar and Rawat, 2011; ENVIS, 2013).

Sr. No.	Taxonomic Groups of Plant Kingdom	No. of Species in Uttarakhand (ENVIS 2013)	No. of Species in India (BSI, 2021)	Per cent of Species in Uttarakhand w.r.t. India
1.	Angiosperms	5,296	21,849	24.24
2.	Gymnosperms	35	82	42.68
3.	Pteridophytes	365	1,310	27.86
4.	Bryophytes	478	2,791	17.13
5.	Algae	346	8,979	3.85
6.	Fungi	-	15,504	-
7.	Lichens	539	2,961	18.20
	Total	7,059	53,476	13.20

Table 2.7Representation of India's
Plant Diversity in Uttarakhand

Source

Compiled from BSI (2021); Bioresources of Uttarakhand (Kumar and Rawat, 2011); Diversity of 'Flora and Fauna of Uttarakhand' (ENVIS, 2013).

Land Use Land Cover

Land Cover indicates the physical land type on the earth's surface in the form of water bodies, vegetation etc., whereas Land Use refers to the human adjustments with the land. The Land Use Land Cover (LULC) pattern of a region is an outcome of natural and socio-economic factors prevailing and their temporal and spatial utilization by man (Agarwal et al., 2019).

In Uttarakhand, an integrated system comprising of farming, forestry, horticulture, livestock rearing and other relevant activities is practiced, which is common for most hill economies. According to the 2018-2019 records of NRSC, Hyderabad. Forest is the major LULC in most of the districts in the state, while districts situated in plane areas i.e., Haridwar and Udham Singh Nagar have majority of area under agriculture. Districts situated in the North-East have significant barren/waste land. Forest accounts for majority share (48 per cent) in the land use pattern of the State, followed by 20 per cent agriculture and 13 per cent wasteland.

2.8

Land Use Pattern

The population of the State depends primarily on agriculture for livelihood; about 70 per cent of the population is engaged in agriculture. Most of the area of State is under forests and wastelands thus leaving only a small amount of land i.e., 7,410 km² (13 per cent) for cultivation out of the total reported area of 56,720 km². Out of the total, about 89 per cent area is under small and sub marginal land holdings. The paucity of arable land on the one hand and growing rural population without alternate rural occupations on the other, leads to smaller holding (IRI, 2018). As large area is under small and marginal holdings, scale of economies cannot be availed of, and so the input cost per unit of output is higher. Most of the agriculture in the state is rainfed. The net sown area of the state has decreased by 0.47 per cent from 7,000 km² in 2014-15 to 6,730 km² in 2017-18 and Current Fallows has increased from 570 km² in 2014-15 to 730 km² in 2017-18 (MOA, 2015 and 2018).

Additionally, unchecked hill tourism has resulted in the huge growth of vehicular traffic, spread of road networks, and the construction of poorly designed and unregulated hotels and housing structures. many of which are near rivers, has essentially affected the Land Use pattern of the state making it ecologically unsustainable and perhaps economically untenable as well.

Socio-Economic Characteristics

One of the prime driver of various threats to FGR is the burden generated by the exponentially increasing population of the State. Total population of the State is 10.08 million comprising 5.13 million males and 4.95 million females, with 30.23 per cent, 69.77 per cent, and 2.89 per cent of the population falling under urban, rural, tribal categories, respectively as per the 2011 census of India. The State represents country's 0.83 per cent population on 1.63 per cent of the land area. The population density of the State is 189 people per km² having a 2001–2011 decadal growth rate of 18.81 per cent. The districts having high population growth includes Udham Singh Nagar, Dehra Dun, Haridwar, Nainital, and Champawat with growth rate with 33.4 per cent, 32.3 per cent, 30.6 per cent, 25.1 per cent and 15.6 per cent, respectively. The districts having high literacy rate include Dehra Dun, Nainital, Chamoli, Pithoragarh and Pauri Garhwal with 84.3 per cent, 83.9 per cent, 82.7 per cent, 82.3 per cent and 82.0 per cent respectively. The gender ratio is 963 females per 1000 males. The crude birth rate in the State is 18.6 births per 1000 individuals with the total fertility rate being 2.3 (Census, 2011).

Human habitation is found up to an altitude of 3,500 m; however, the zone between 1,200 - 2000 m, largely falling in the Lesser Himalaya, is densely populated. The decennial growth rate of the population of the State for the decade 1991-2001 was 19.20. In this region the human population is continually increasing and the region is experiencing major difficulties in sustaining its growing population on its squeezing environmental resources-land availability, forests and grasslands, water resource, etc. (WMD, 2008)





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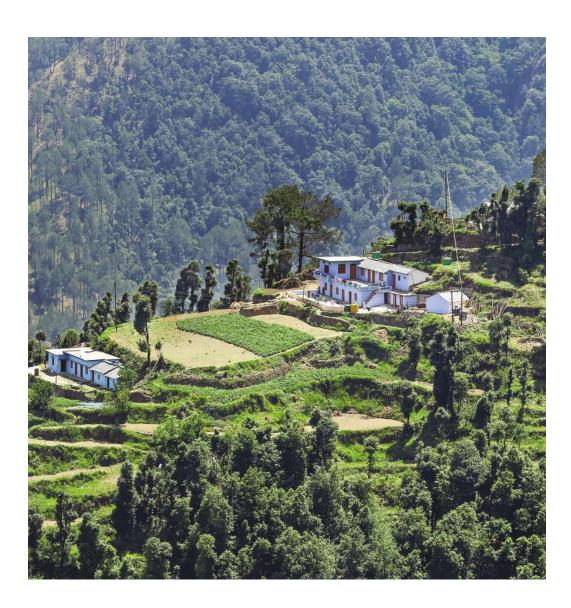
2.10

Agroecosystem

Agriculture is one of the most significant sectors of the economy of Uttarakhand and net sown area is 6,730 km² (FSI, 2021). The landholding of the people is very small. Most of the families own about half hectare of land, much of it is un-irrigated and with low productivity. Rice, wheat, maize, barley, coarse cereals (*manduwa*, *sanwan*, etc.), pulses, oilseeds, sugarcane, potato and vegetables are the most widely grown crops. Fruits like apple, orange, pear, peach, litchi, and plum are widely grown and important to the large food processing industry. The people mostly practice subsistence farming. About 33 per cent of the total area in Uttarakhand is either rocky/ snow covered/ glaciated or otherwise unproductive and degraded land. About 12 per cent of agricultural land has got irrigation and about 90 per cent land is used for growing cereals, fodder (*berseem*) and some vegetables (WMD, 2008).

Although almost 70 per cent of the population is dependent of the primary sectors, the contribution of this sector of the GDP/ NDDP is only 37.5. As a result, it does not provide sufficient income levels to the people. This subsistence nature, which leads to low incomes and unstable incomes, which in turn lead to a sizeable out-migration of male members that leads to only women headed families behind, and the role of women in the household economy becomes more important (WMD, 2008).

Rearing of livestock is an integral part of rural occupation. The 20th Livestock Census 2019 has reported a total livestock population of 9.67 million in the State which comprises 0.96 per cent cattle, 0.79 per cent buffaloes, 0.38 per cent sheep, 0.92 per cent goats, 0.20 per cent pigs, and 0.59 per cent poultry of the country's total livestock population. There has been a significant increase in the population of crossbred cattle and decrease in indigenous cattle population. Collection of grass and leaf fodder is an essential part of daily chore for the people, especially women. Grazing animals pose the greatest challenge to forest regeneration and plantation establishment in the hills.



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2.11

Forest Resource Dependence

More than 90 per cent of the rural population of the State is fully or partially dependent on the forest for fuel besides many other resources. The cold climatic conditions. particularly in the upper reaches of the State necessitates consumption of fuel wood for the purpose of heating for want of modern and alternative means. The rural people in most of the remote areas have a unique and special relationship with forests that directly support their



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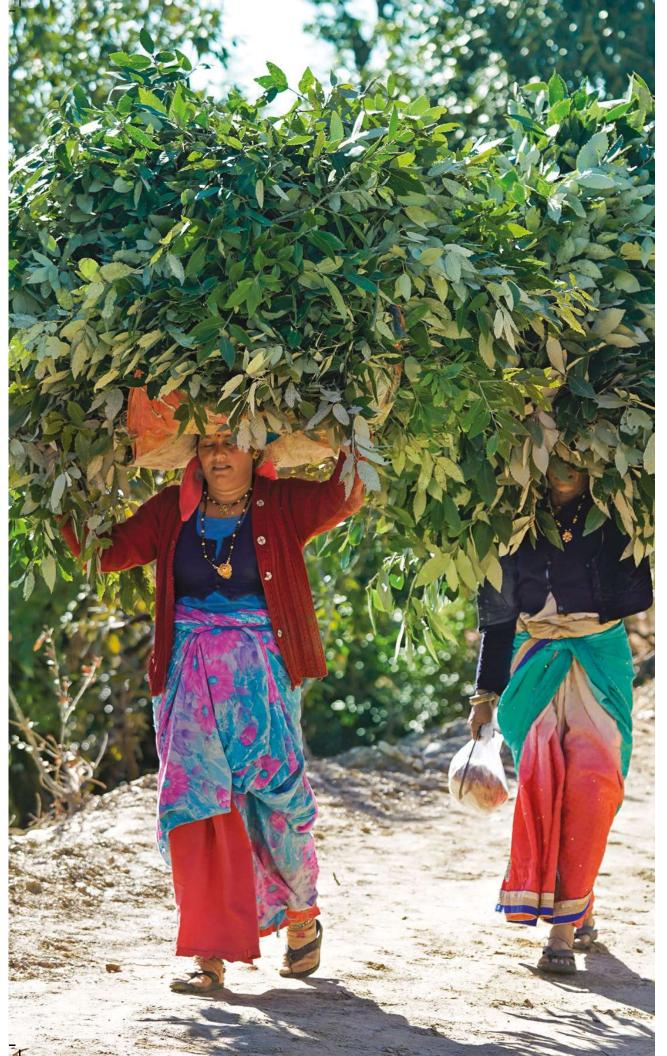


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livelihoods. The rural population of Uttarakhand plays a pivotal role in the preservation of the forest wealth of the nascent state by their traditional practices and self-imposed rules, implemented through Van Panchayats and sacred groves. The contribution and initiative of local communities in the conservation of forests in the State has been based on the traditional knowledge of these hill people. In addition to the fragile ecosystem, the increasing population with deficient agricultural production, large and unproductive bovine population, scanty returns from NTFPs and degraded community forests constitute a vicious cycle of poverty resulting in tremendous pressure on forests in the region (Farooquee and Maikhuri, 2007). As per FSI (2021), Rhododendron arboreum, Myrica esculenta, Lannea coromandelica, Ehretia laevis, and Taxus wallichiana are the major species contributing towards NWFPs in Uttarakhand.

Forests provide fodder in the form of tree leafs and grasses from both sub-tropical and temperate grasslands. The areas of mountainous mainland that falls under temperate forests are rich in fodder and consequently milk production in these areas is high. Pine and oak leafs are also used to make animal beds and manure. Firewood is used for cooking food and warming house by about 90 per cent rural people. It is generally obtained from pine and oak trees, which are extensively found in the midaltitudes and the highlands, respectively. Timber is used for making houses and furniture. There are seasonal wild fruits with high nutrient value which are harvested in plenty, viz., Kafal (Myrica esculenta), Hisalu (Rubus ellipticus), Bedu (Ficus palmata), Timla (Ficus auriculata), Khubani (Prunus armeniaca), etc. Apart from this substantial amount of resin is extracted from pine trees and bark of oak is used for making agricultural tools and Uttarakhand contributes a significant volume of these resources for the whole country (Sati and Bandooni, 2018).

A detailed study on Forest Resource Dependence and Ecological Assessment of Forest Fringes in Rainfed District of India' was conducted by FRI, and one of the major outcomes of this study was quantifying the amount of fuelwood, fodder, and other NWFPs extracted from the forest areas in the rainfed districts and States of the country. It was noted that the forest fringe villages of Uttarakhand depend heavily on the forest resources for fuelwood, fodder, and other NWFPs (FRI, 2017). A total of 4.39 million t of fuelwood was reported to be consumed by residents of forest fringe villages in the rainfed districts of the State largely for cooking and heating purposes. The fuelwood consumption was documented to be highest in Tehri Garhwal (667.80 kg month⁻¹) and lowest in Nainital (366 kg month⁻¹). The average monthly fuelwood consumption in Uttarakhand (469.50 kg month⁻¹) was much higher than the national average of 121.19 kg month⁻¹ as given by Woodbridge et al. (2011). It is evident from the ongoing account that Forests of Uttarakhand are under immense pressure of providing for an everincreasing population of the State and hence, their conservation effort needs to be ameliorated with advanced research and technological support. Sustainability in pattern of collection and consumption of resources from forests forms one of the primary approaches towards conservation of FGR and hence needs to be taken into consideration at all levels. The unique characteristics and an opulent resource base of Uttarakhand summarized in the above section has highlighted the magnificent yet vulnerable ecosystem of the State which can benefit immensely from scientifically planned conservation strategy. The Pilot Project is one such step towards furnishing the baseline information about the State's FGR by adopting a multi-component approach designed to cover various aspects of FGR conservation outcomes of which is discussed at length in the following parts of this book.



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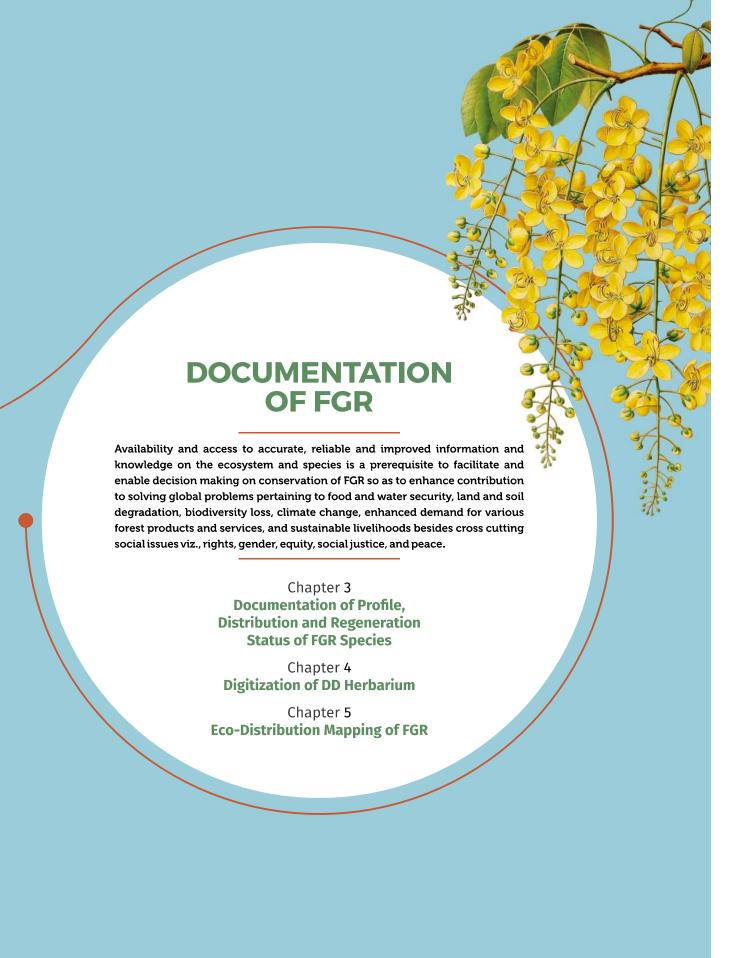
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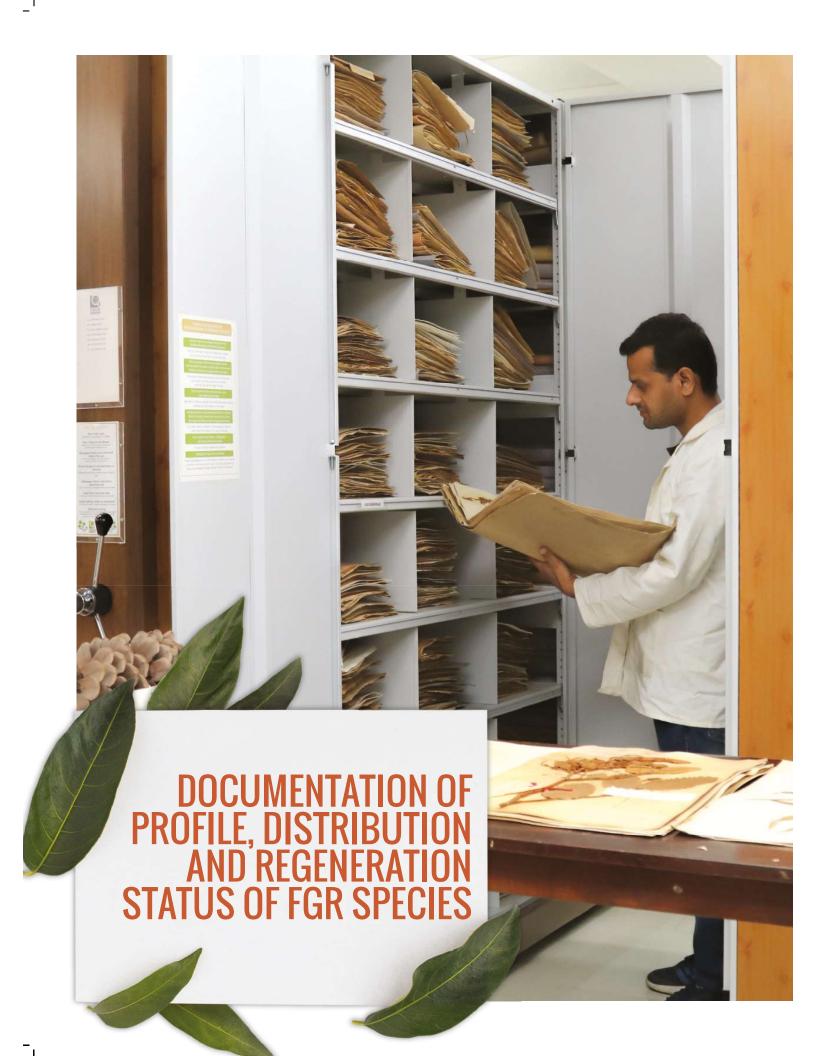


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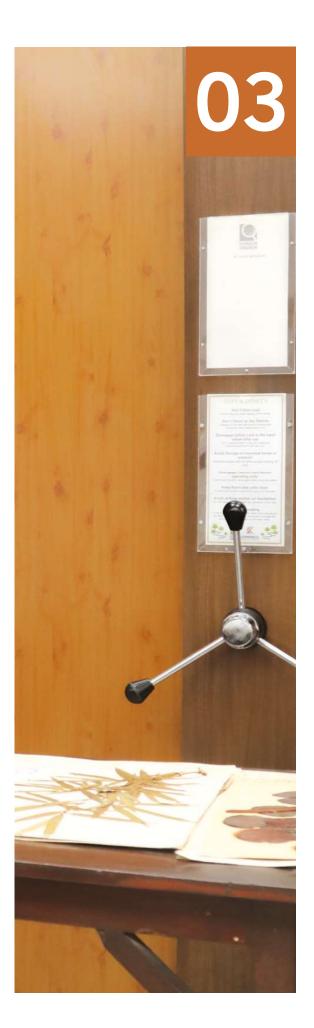












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> India as a country as well as Uttarakhand province, the project demonstration State are home to a wide array of native. non-native and naturalized tree, shrub, and other forest/plant species that have adapted in various ways to their growing environments. Some of this plant diversity has evolved naturally over generations as species have adapted at a fine scale to local conditions while in other cases, diversity is the product of deliberate efforts over past decades to develop varieties that are productive. Environmental factors viz., climate, soils, and pathogens besides human induced activities vary widely in nature and intensity across the country as well as in the State of Uttarakhand and all these factors influence forests and its enormous diversity of FGR. In general, the current knowledge on biodiversity, FGR in particular is elementary, inaccessible and inadequate in most instances primarily for the reasons: (a) vastness and high diversity of forest ecosystems. associated species and their processes; (b) long lived tree resources; (c) complex and dynamic nature of vegetation; (d) multidiscipline, multiscale, multisector and multistakeholder wider subject of FGR; (e) insufficient research, monitoring, and databases: and (f) unchecked and unassessed extraction of forest resources by local communities.

3.1

Need for Improved Information and Access to Knowledge

In spite of the long history of forest management, documentation of FGR has mainly confined to select economically important species out of enormous forest plant diversity. Vital information on the distribution of forest types and sub-types for the country/ states even updated by FSI is not easily accessible to wider users (scientists, researchers, entrepreneurs, etc.). Most explorations, surveys and collection for forest botany and floristics in majority cases have been quite old, and the structure and composition of forests have altered significantly owing to vegetation succession, enhanced biotic activities, climate change, selection fellings, large scale transportation of germplasm from one place to the other, plantations of introduced and exotic species, and more recently proliferation of invasive species.

In India as well as in the case of Himalayan State of Uttarakhand, naturalists, foresters and botanists have collected, preserved, catalogued and systematically stored plants as herbarium specimens for past two centuries or so for taxonomic research so as to record the flora of a region and to document their economic uses. In the ensuing period of more than a century, enormous changes have taken place in floristic research, in taxonomy and nomenclature of flowering plants with gaining momentum of progressive applied research and inclusion of data from biogeography, ecology, environment induced phenotypic changes, molecular sciences, knowledge of local people, and emergence of taxonomy as an interdisciplinary subject in quest of economic and ecological potentials of plants or on product development. With the passage of time, not only the traditional subject of botany and taxonomy lost its charm, but also on one hand the pool of plant taxonomists and para-taxonomists has drastically declined while on the other hand, confusions on plant nomenclature arose due to recent molecular based modifications in phylogenetics, emergence of new names, and merging of synonyms. The situation is further aggravated in the absence of adequate insight on the past and current distribution of the species, fragmented populations and small size, threats, and regeneration status. In view of this, an updated documentation of species profile incorporating vital information on taxonomy, distribution, status and trends to deal with any program relevant to the management of FGR is of paramount importance and inevitable as the foremost step. Further, development of effective strategies towards conservation of FGR now seek supplemental information from the perspective of habitat variability, and inter and intra-specific biological variation as the starting point for high adaptability of the species/ population based on the molecular sciences besides potential ecological and economical superiority on the account of seed vigour and germplasm storage capacity, physiological and biochemical characterization, and their resistance to pest and pathogens.

3.2

Population structure and regeneration status

Change in the floristic diversity is inevitable on account of natural and human induced factors. Enhanced anthropogenic activities in recent times have resulted into profound rate of change in such diversity. As a result, population structure and regeneration patterns of species have also been greatly influenced (North et al., 2004). This necessitates regular exploration, survey and documentation of composition and distribution of floristic information. Moreover, forests are natural renewable resource only because they can regenerate themselves. The natural plant regeneration is critical for conservation of biodiversity and FGR. The ability of a species to complete its lifecycle and key processes for its survival in a community under altered environmental conditions has been referred as the regeneration potential. Regeneration is a process by which seedlings and coppice naturally establish themselves in an area where plants have died or been killed. The population density of seedlings, saplings and adult trees provides fair idea of the population structure and regeneration status of any forest community. The generation and spread of seeds, their germination and subsequent growth and survival of seedlings and saplings until they reach maturity and begin producing seeds on their own constitute the renewable aspect of a tree or other species in a forest (Rao, 1988). Assessing population structure and regeneration state of tree species in a forest certainly offers an insight into future changes in the forest's structure and species composition (Henle et al., 2004). An uninterrupted regeneration and appropriate growth of all species is vital in the presence of older and matured plants in the development and expansion of any plant community (Taylor and Zisheng, 1988).

A tree with adequate number of seedlings, saplings and young individuals reflects good regeneration while a tree with insufficient number of seedlings, saplings and young individuals shows poor regeneration. Forest species without seedlings and saplings denotes no regeneration (Khan *et al.*, 1987; Saxena *et al.*, 1984). A wide array of anthropological factors is exerting pressure on forests and obviously on pivotal regeneration of forest species (West *et al.*, 1981).



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3.3

Gaps in Information, Priorities and Strategies for Documentation

Documentation of FGR and reliable information on forest status and trends are not only of great importance but also a foundation of any state, nation, region, global level conservation program or initiative. Currently, most available forest-related information primarily pertains to forest resources in general rather than to forest diversity and variation in tree species. Although BSI, FSI, FRI, WII, GBPIHESD, ICFRE and its institutes, UKFD, and several other national/ state level governmental and non-governmental organizations have been contributing information on varied aspects of FGR, the availability of specific and organized information on the status and trends in FGR is either inadequate or widely scattered or even inaccessible. The Global Plan of Action on FGR by FAO-CGR also highlighted gaps in information in terms of: (a) updated species checklist; (b) an accurate state/ national/ regional/ global picture of the status and trends of FGR; (c) knowledge of the reproductive and development characteristics for effective *in situ* and *ex situ* conservation, particularly for production of seedlings, planting and development of such species outside their natural habitats; (d) understanding on relationship between the use and management of FGR and traditional knowledge; (e) inadequate monitoring indicators and protocols; and (f) lack of a comprehensive assessment of capacities at various levels to manage FGR (FAO, 2014b).

Owing to limited time and resources, often a full inventory is considered impossible. Hence, prioritization of species, activities/ variables for cataloguing and mapping are essential. However, information on species taxonomy, species associations, ecological communities, habitats, natural processes, ecosystems, distribution, regeneration status, and anthropogenic disturbances and processes are important elements for setting priorities and sampling. Moreover, large-scale inventory programs at the state/ national level require rigorous application of standardized, quantitative and repeatable documentation protocols. Datasets need to be comparable not only between studies at different times to meet the needs of long-term monitoring but also comparable among sites at the state, national, regional or global scales. This necessitates accuracy and methods used in data collection; identifying the levels of information, techniques, tools and technology; and standard protocol of presentation for ease of interpretation of information by users besides standard transfer formats, bibliographic servicing and a network of information exchange are important aspects of documentation and improved information (Fleming and Aagaard, 2010).

In view of the above, the pilot project in Uttarakhand envisaged development of species inventories and profiles, assessment of threats, distribution, population structure, regeneration status and ecodistribution mapping. Three sequential chapters in Part II of this book cover these aspects. The present chapter specifically focuses on floristics, threat perception, distribution, population structure, and regeneration status relevant to FGR.

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3.4

Study Objectives

The study aimed to provide an updated documentation on prioritized FGR in the State of Uttarakhand and set-forth the following objectives:

- (a) Engage stakeholders, particularly subject specialists for prioritization of FGR species in the state.
- (b) Update inventories and profiles of prioritized FGR species.
- (c) Evaluate threat perception on species of concern.
- (d) Develop an understanding on the distribution of selected species.
- (e) Assess population structure and regeneration status of prioritized species.
- (f) Identify field sites for in situ conservation (forest gene bank and field gene bank)
- (g) Collect specimens and germplasm for ex situ conservation.

3.5

Material and Methods

The multipronged approach adopted for present investigation to achieve above stated objectives included: (a) review of existing information; (b) extensive consultative process; (c) field visits, explorations and assessments; and (d) collection of specimens and germplasm. Specific details on these sub-components of overall approach are elaborated below:

3.5.1

Review of Existing Information on Forest Floristics

The review of existing information on forest floristics in context of Uttarakhand primarily included consultation of floras, forest working plans, herbaria, scientific reports, theses/ dissertations, research papers, and monographs. This review immensely helped in updating information on FGR species, their taxonomy, associated species, past and current distribution, threats, silvicultural practices, etc. required for the present study on documentation. The team involved in the present investigations and documentation has privilege of access to one of the oldest and well-known forest-based herbaria at FRI, internationally known as Dehra Dun Herbarium (DD Herbarium); the repository of information wealth on Indian forestry through the National Forest Library and Information Center (NFLIC), FRI; arboretum; bambusetum within FRI campus; and easy approach to reputed forestry and other allied national level organizations located in proximity.

3.5.2

Consultative Process and Prioritization of FGR Species

Based on above review and professional knowledge, the second important step involved was on consultative process with professionals and subject specialists, particularly botanists, taxonomists, geneticists, pathologists, biochemists, GIS experts and forest managers. The primary objective of consultation with experts was to prioritize FGR species for inclusion in the pilot project. The criteria for prioritization employed included focus on: (a) native and indigenous species; (b) woody perennial; (c) ecologically significant species; (d) species having economic importance; and (e) rare, endangered and threatened species.



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3.5.3

Field Exploration, Surveys and Collection of Samples and Germplasm

The Uttarakhand Forest Department (UKFD) is the custodian of diverse forests along a notable altitudinal gradient covering an extent of 38,000 km² under RFA and responsible for their management and conservation (FSI, 2021). As stated earlier in Chapter 2, forests in the State are being managed by 284 forest ranges under 44 forest divisions and supervision of 17 forest circles. Additionally, 12,168 Van Panchayats having cumulative forest land to the extent of 7,325.89 km² constituted field areas for exploration, surveys, assessments and collection of germplasm. The FSI has delineated nine forest types and 45 forest sub-types based on the forest type classification by Champion and Seth (1968) in the

context of Uttarakhand (FSI, 2021). This included six categories of grassland and alpine pasture types. Additionally, the category of TOF/ Plantation was also recorded. The project team comprising botanists, taxonomists, and field biologists involved in present investigations made concerted efforts to visit varied field sites across different FDs, van panchayats, and protected areas so as to cover different forest types and sub-types for collecting the first-hand information on the occurrence of species, associated plant communities, distribution of populations, assessment of threats, etc. Information on distribution of prioritized species was extracted from varied literature sources as stated above. Extracted and synthesized information on species distribution based on consultation of existing literature, a predetermined strategy keeping in view the likely distribution of prioritized FGR species was framed and followed for planning field visits. A pictorial field book depicting image of plant and its parts, scientific and local name, and other relevant information for the species was prepared to assist in the field work and assessment. Two stage stratified random sampling i.e., at the forest type and forest division levels was used for survey and field level assessments. During field surveys in different forest types and FDs, locations of populations of prioritized FGR species were recorded using hand hold GPS device. In the process of extensive and intensive field surveys, field teams also ensured to identify potential sites for in situ conservation and collected field specimens for herbarium, seeds and other germplasm for planned efforts towards ex situ conservation. Field surveys and assessments on prioritized species were undertaken in different parts of the State during 2016-2021. Field activities were hampered for almost one year i.e., March, 2020 onwards due to Covid-19 pandemic and resultant lockdown.

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3.5.4

Assessment of Population Structure and Regeneration Status

Field level assessments on population structure and regeneration status of prioritized FGR species across different forest divisions and forest types in the state formed an integral part of field visits and surveys. Regeneration data was collected from the natural distribution range of the species. Forty to eighty nested quadrats were randomly laid down in each of the forest type depending upon the extent. For tree, shrub and herb layers, quadrats of size $10 \text{ m} \times 10 \text{ m}$, $3 \text{ m} \times 3 \text{ m}$, and $1 \text{ m} \times 1 \text{ m}$ were used, respectively. Altogether, during the currency (six years) of the project, field studies in 34 FDs including Soil Conservation, Civil Soyam, and Wildlife/ PA divisions were carried out. Out of 45 forest sub-types, sampling could be carried out in 37 forest sub-types only as sampling in two forest sub-types (Bhabhardun Sal Forest and West Himalayan Dry Juniper Forest), and six grassland and alpine pasture types could not be undertaken on account of either small extent or non-representation of prioritized FGR species in such sub-types. In all, 199 forest ranges were covered and 5,290 nested quadrats were laid for assessment on tree, shrub, and woody climber diversity, population structure and regeneration status (Table 3.1). This way, tree layer diversity, population structure and regeneration status were assessed in cumulative area of 0.529 km^2 representing 0.002 per cent extent of overall $23,749.84 \text{ km}^2$ forest cover under sampled 34 forest types (FSI, 2021).

Table 3.1
Details of
Sampled
Quadrats in
Different
Forest
Divisions,
Uttarakhand
and Forest
Ranges
Covered Under
Sampling

Sr. No.	Forest Divisions		Forest Ranges	No. of Nested Quadrats
		Total	Covered Ranges- Number and Names	
1.	Alaknanda Soil Conservation	7	3 (Ased Simli, Nandakin and Pipalkoti)	60
2.	Almora	8	5 (Almora, Ranikhet, Jaurasi, Dwarahat and Almora)	100
3.	Badrinath	6	3 (West Pindar, Nandprayag and Chamoli)	80
4.	Bageshwar	6	5 (Dharamdhar, Baijnath, Bageshwar, Kapkot and Glacier)	200
5.	Chakrata	6	6 (Rikhnar, River, Kanshar, Devdhar, Daragad and Molta)	360
6.	Champawat	7	5 (Devidhura, Boom, Kali Kumaon, Lohaghat and Champawat)	300
7.	Civil Soyam, Pauri	7	3 (Satpuli, Pavo and Pauri)	60
8.	Civil Soyam, Almora	7	3 (Jageshwar, Binsar and Kanarichhina)	60
9.	Dehradun	8	8 (Thano, Rishikesh, Malhan, Jhajhra, Asharodi, Malsi, Lachhiwala and Badkot)	480
10.	Gangotri National Park	1	1 (Gangotri)	30
11.	Govind wildlife sanctuary	3	3 (Rupin, Supin and Sankari)	160

Sr. No.	Forest Divisions		Forest Ranges	
		Total	Covered Ranges- Number and Names	
12.	Haldwani	6	6 (Haldwani, Sharda, Danda, Jaulasal, Nandhour and Chakata)	360
13.	Haridwar	7	5 (Khanpur, Haridwar, Shyampur, Jhilmil jheel, and Chidiyapur)	300
14.	Corbette Tiger Reserve	6	2 (Maidawan, Bijrani)	40
15.	Kedarnath Wildlife	6	3 (Nagnath, Ukhimath and Gopeshwar)	60
16.	Lansdowne	5	4 (Lansdowne, Kotdi, Kotdwar and Laldhang)	60
17.	Mussoorie	6	6 (Bhadrigad, Raipur, Mussoorie, Devalsari, Jaunpur and Kempty)	360
18.	Nainital	7	5 (Bhowali, Manora, Naina, South Gaula and Kosi)	100
19.	Nanda Devi National Park	2	2 (Valley of flowers and Joshimath)	60
20.	Narendra Nagar	3	2 (Shivpuri and Saklana)	60
21.	Pithoragarh	7	7 (Askot, Didihat, Gangolihat, Berinag, Munsiyari, Dharchula and Pithoragarh)	450
22.	Rajaji National Park	9	6 (Chilla, Chilawali, Haridwar, Dhaulkhnad, Motichur and Gahori)	180
23.	Ramnagar	5	5 (Kosi, Fatehpur, Kaladungi, Dehchauri and Kotta)	200
24.	Rudraprayag	6	5 (South Jakholi, North Jakholi, Agastyamuni, Rudraprayag and Khankra)	120
25.	Soil Conservation, Kalsi	7	6 (Langha, Timali, Quanu, Chakrata,Churani and Kalsi)	180
26.	Soil Conservation, Nainital	3	1 (Mukteshwar)	30
27.	Terai Central	7	2 (Tanda and Pipalpadav)	60
28.	Terai East	8	6 (Gaula, Dolly, Kishanpur, Kilpura, Khatima and Jaulasal)	180
29.	Terai West	7	3 (Ramnagar, Belparao, South Jaspur)	60
30.	Tehri Dam -1	6	4 (Balganga, Nailchami, Tehri and Surkanda)	60
31.	Tehri	5	4 (Devtadana, Tehri, Balganga and Bhilangna)	120
32.	Tons	5	5 (Singatoor, Devata, Sandra, Kotigad, Purola)	100
33.	Upper Yamuna	5	2 (Naugaon and Kuthnour)	60
34.	Uttarkashi	5	6 (Barahat, Gangotri, Taknaur, Dunda, Mukhem and Dharasu)	200
	Total	199	142	5,290

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Analysis for tree density was estimated following Misra (1968). In each quadrat, girth at breast height (gbh) i.e., $1.37\,\mathrm{m}$ above ground level of each tree was measured. In case of individuals of herb and shrub layer, diameter was recorded at $2.5\,\mathrm{cm}$ above ground level. Seedlings, saplings and adult trees were considered as per diameter $< 2\,\mathrm{cm}$, $2\,\mathrm{cm}$ - $10\,\mathrm{cm}$ and $> 10\,\mathrm{cm}$, respectively. Diameter at breast height (DBH) of adult individuals was estimated and categorized into different diameter classes. Regeneration of woody species was determined based on population size of seedlings, saplings and adults and categorized as per Dutta and Devi (2013), modified from Khan et al. (1987); Shankar (2001), and Khumbongmayum et al. (2006). The following categories were used for designation of regeneration status in case of tree species:

- Good regeneration: if density of seedlings > saplings > adults
- Fair regeneration: if density of seedlings > or ≤ saplings ≤ adults if seedlings ≤ saplings > adults if seedlings ≥ saplings and the species had no adults
- Poor regeneration: if a species survives only in the sapling stage, but no seedlings (though saplings may be <, >, or = adults)
- No regeneration: if it is absent both in seedling and sapling stages but found only in adults
- New regeneration: if the species has no adult tree, but only saplings or seedlings

As there were no specified categories available for shrub and climber species, the following categories were considered to designate the regeneration status for them:

- Good regeneration: if seedlings > saplings
- Fair regeneration: if seedlings ≤ saplings
- No regeneration: if species has only saplings, no seedling
- · New regeneration: if species has only seedlings, no sapling

GIS based maps on forest types for Uttarakhand were generated by FRI GIS team availing the data from FSI. All field data on distribution of species was collected and analyzed for two levels: (a) forest division-wise and (b) forest type-wise, while data on population structure and regeneration status was analyzed on the basis of forest types in the state.



Research Findings

Research findings based on state-wide field effort over a period of five years besides other activities yielded valuable insight on the current taxonomy of prioritized species, their distribution, threats, population structure and regeneration status. Findings are presented in the following three sections:



Prioritized FGR Species

The plant diversity in the world, India as well as the State of Uttarakhand have been summarized in the preceding sections 1.11.1, 1.11.2, and 2.6, respectively. An approach to estimation of FGR (trees and other woody species) in forests has also been elaborated in the context of India in the section 1.11.7. Accordingly, India has an estimated FGR diversity of 8,733 species. On similar lines, the estimated FGR diversity in Uttarakhand amounts to about 2,132 species (total angiosperms and gymnosperms-5,331 out of recorded plant diversity of 7,059 species; 50 per cent of 5,331 species is herbaceous i.e., 2,666 species; and 80 per cent of 2,666 i.e., 2,132 are FGR species). As per this, the Himalayan State of Uttarakhand with country's megre 1.69 per cent geographical area harbours 24.41 per cent FGR diversity of the country. This higher proportion of FGR species in Uttarakhand is obviously due to the fact that the State exhibits enormous diversity of landforms across altitudinal gradient ranging from 250 m to 7,817 m; harbours 24,305.13 km² extent of forest cover or 45.44 per cent of the State's GA; and represented by five Forest Types, nine Forest Type Groups, and 45 Forest Sub-Types including six categories of grasslands and alpine pastures besides TOF/ plantations.

Uniyal *et al.* (2007) have provided a detailed account on flowering plants of Uttarakhand and described ca. 4,698 species under 1,503 genera and 213 families, accounting 27 per cent of the angiospermic flora of the country. According to them, the State harboured 4,666 angiosperms and 32 gymnosperms. Notably, the State hosts ca. 50 per cent genera of the Indian flowering plants. The dicots dominated with ca. 3,493 species under 1,163 genera and 182 families, while the monocots were represented by ca. 1,173 species belonging to 343 genera and 31 families. Gymnosperms were represented by 20 genera and 32 species. The breakup of plant diversity in Uttarakhand based on habit is provided in Table 3.1. Accordingly, the habit wise distribution of plant diversity was represented by 362 trees, 615 shrubs, 167 woody climbers, 125 herbaceous climbers, and 3,429 herbs out of total 4,698 species. This included 108 RET species (Table 3.1).

Based on the consultative process, involving subject specialist/ experts mainly botanists, taxonomists, wildlife scientists, and conservationists associated with forest-based plant diversity in the State, altogether 250 species of FGR were prioritized based on the broad criteria mentioned in above section 3.5.2 and selected for the purpose of documentation as a part of the present investigations described in this chapter. Out of 250 species, 62 were RET species. Selected 250 FGR included 180 tree, 47 shrub, and 23 woody climber species. Thus, 72 per cent selected FGR in the Pilot Project in the Himalayan State were represented by tree species, followed by 13.77 per cent woody climbers and 7.64 per cent shrub species (Table 3.2). Selected 180 tree species in the Project represented almost 50 per cent of the total tree diversity recorded in the State. Further, in view of the definition of FGR, herbaceous flora was excluded from the exercise of prioritization. The selected 250 FGR for the present investigations belonged to 88 plant families. Family-wise details on prioritized species selected in the present study are provided in Table 3.2. The prominent 11 families with higher number of selected FGR species (7 to 15) in the descending order were: Fabaceae (15), Lauraceae (10), Moraceae (10), Berberidaceae (9), Euphorbiaceae (9), Mimosaceae (9), Rosaceae (9), Anacardiaceae (7), Caesalpinaceae (7), Pinaceae (7), and Rubiaceae (7) (Table 3.3).



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In Uttarakhand **Present Study** Sr. Habit **No. of Species** RET **Total** No. of RET **Total Per Cent** No. (excluding RET) **Species** of (excluding Selected RET) **Species** 1. 49.72 Trees 328 34 362 146 34 180 2. 595 20 7.64 Shrub 20 615 27 47 3. Woody Climber 159 8 167 15 8 23 13.77 4. 0 0 0 0 0 125 125 Herbaceous climber 5. 3,383 3,429 0 0 0 0 Herb 46 Total 4,590 108 4,698 188 62[°] 250

Table 3.2
Habit-wise Prioritized FGR
Species for the Pilot Project
in Uttarakhand

*RET species selected in the present study based on consultative workshop.

SourceCompiled from Uniyal *et al.*(2007)

		In Uttarakhand			Present Study				
Sr. No.	Family	No. of Species (excluding RET)	RET	Total	No. of Species (excluding RET)	RET	Total	Per Cent	Total Selected Species
1.	Acanthaceae	58	0	58	2	3.45	0	0	2
2.	Aceraceae	13	0	13	3	23.1	0	0	3
3.	Actinidiaceae	0	1	1	0	0	1	100	1
4.	Alangiaceae	2	0	2	1	50	0	0	1
5.	Anacardiaceae	13	0	13	7	53.8	0	0	7
6.	Annonaceae	2	0	2	1	50.0	0	0	1
7.	Apocynaceae	14	1	15	4	26.7	1	6.67	5
8.	Aquifoliaceae	3	2	5	0	0	2	40	2
9.	Araliaceae	10	3	13	0	0	3	23.1	3
10.	Arecaceae	4	3	7	2	28.6	3	42.9	5
11.	Aristolochaceae	2	1	3	0	0	1	33.3	1
12.	Asclepidiaceae	45	0	45	3	6.67	0	0	3
13.	Asteraceae	417	1	418	0	0	1	0.24	1
14.	Berberidaceae	26	6	32	3	9.38	6	18.8	9
15.	Betulaceae	7	0	7	6	85.7	0	0	6
16.	Bignoniaceae	4	0	4	2	50.0	0	0	2
17.	Bombacaceae	1	0	1	1	100	0	0	1
18.	Boraginaceae	54	0	54	1	1.85	0	0	1
19.	Burseraceae	2	0	2	2	100	0	0	2
20.	Buxaceae	3	0	3	1	33.3	0	0	1
21.	Caesalpinaceae	22	0	22	7	31.8	0	0	7
22.	Capparaceae	8	0	8	1	12.5	0	0	1
23.	Caprifoliaceae	26	1	27	0	0	1	3.70	1
24.	Celastraceae	15	1	16	2	12.5	1	6.25	3
25.	Cochlospermaceae	0	1	1	0	0	1	100	1
26.	Combretaceae	8	0	8	5	62.5	0	0	5
27.	Convulvulaceae	40	1	41	0	0	1	2.44	1
28.	Cornaceae	3	0	3	2	66.7	0	0	2
29.	Cupressaceae	6	0	6	2	33.3	0	0	2
30.	Cyatheaceae	0	1	1	0	0	1	100	1
31.	Daphniphyllaceae	2	0	2	1	50.0	0	0	1
32.	Datiscaceae	0	1	1	0	0	1	100	1
33.	Dilleniaceae	1	0	1	1	100	0	0	1
34.	Dipterocarpaceae	1	0	1	1	100	0	0	1
35.	Ebenaceae	5	0	5	2	40	0	0	2
36.	Elaeagnaceae	9	0	9	2	22.2	0	0	2
37.	Elaeocarpaceae	1	1	2	0	0	1	50	1
38.	Ephedraceae	2	0	2	1	50	0	0	1

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Table 3.3Family-wise Distribution of FGR Species in Uttarakhand and Selected Species for the Pilot Project

*FGR Species selected based on consultative workshops on prioritization

Source Compiled from Uniyal *et al.* (2007)



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		In Uttarakhai	nd		Present Study				
Sr. No.	Family	No. of Species (excluding RET)	RET	Total	No. of Species (excluding RET)	RET	Total	Per Cent	Total Selected Species
39.	Ericaceae	13	0	13	1	7.69	0	0	1
40.	Euphorbiaceae	74	3	77	6	7.79	3	3.9	9
41.	Fabaceae	351	4	355	11	3.1	4	1.13	15
42.	Fagaceae	6	0	6	5	83.3	0	0	5
43.	Flacourtiaceae	6	0	6	1	16.7	0	0	1
44.	Hippocastanaceae	1	0	1	1	100	0	0	1
45.	Juglandaceae	3	0	3	2	66.7	0	0	2
46.	Lardizabalaceae	2	0	2	1	50	0	0	1
47.	Lauraceae	18	3	21	7	33.3	3	14.3	10
48.	Lecythidaceae	2	0	2	1	50	0	0	1
49.	Liliaceae	63	0	63	1	1.59	0	0	1
50.	Lythraceae	12	0	12	1	8.33	0	0	1
51.	Magnoliaceae	1	1	2	0	0	1	50	1
52.	Malpighiaceae	4	0	4	1	25	0	0	1
53.	Malvaceae	30	0	30	1	3.33	0	0	1
54.	Meliaceae	7	1	8	4	50	1	12.5	5
55.	Menispermaceae	9	0	9	2	22.2	0	0	2
56.	Mimosaceae	23	2	25	7	28	2	8	9
57.	Moraceae	41	2	43	8	18.6	2	4.65	10
58.	Moringaceae	1	0	1	1	100	0	0	1
59.	Myricaceae	1	0	1	1	100	0	0	1
60.	Myrtaceae	4	0	4	2	50	0	0	2
61.	Olacaceae	1	1	2	0	0	1	50	1
62.	Oleaceae	22	3	25	3	12	3	12	6
63.	Pinaceae	7	0	7	7	100	0	0	7
64.	Pittosporaceae	1	1	2	1	50	1	50	2
65.	Punicaceae	1	0	1	1	100	0	0	1
66.	Ranunculaceae	110	0	110	2	1.82	0	0	2
67.	Rhamnaceae	26	2	28	4	14.3	2	7.14	6
68.	Rhizophoraceae	0	1	1	0	0	1	100	1
69.	Rosaceae	177	3	180	6	3.33	3	1.67	9
70.	Rubiaceae	69	2	71	5	7.04	2	2.82	7
71.	Rutaceae	17	0	17	4	23.5	0	0	4
72. 73.	Salicaceae Sapindaceae	16 2	0	16 2	2	12.5	0	0	2
74.	-	4	0	4	1 2	50 50	0	0	2
75.	Sapotaceae Saurauiaceae	0	1	1	0	0	1	100	1
76.	Schisandraceae	1	1	2	0	0	1	50	1
77.	Simaroubaceae	1	0	1	1	100	0	0	1
78.	Smilacaceae	12	0	12	1	8.33	0	0	1
79.	Staphyleaceae	0	2	2	0	0.33	2	100	2
80.	Sterculiaceae	10	0	10	3	30	0	0	3
81.	Symplocaceae	5	1	6	0	0	1	16.7	1
82.	Taxaceae	1	0	1	1	100	0	0	1
83.	Theaceae	3	1	4	0	0	1	25	1
84.	Tiliaceae	17	0	17	2	11.8	0	0	2
85.	Toricelliaceae	0	1	1	0	0	1	100	1
86.	Ulmaceae	10	0	10	5	50	0	0	5
87.	Urticaceae	45	1	46	2	4.35	1	2.17	3
88.	Verbenaceae	33	0	33	4	12.1	0	0	4
	Total	2,092	62	2,154	188	-	62	-	250

3.6.2

Species Profile - Distribution and Threat Perception

The importance of reliable data on forest status and trends for the efficient management of FGR has already been highlighted. Currently, available forest related information largely relates to forest resources in general rather than to forest diversity and variation in tree and other woody species. The specific information on the status and trends in FGR in the context of India as well as the pilot State of Uttarakhand is inadequate despite India has made notable progress in terms of botanical explorations, forest botany, systematics and taxonomy, establishment and development of herbaria, and preparation of national and state level plant checklists and floras in the past two centuries or so. However, often the available botanical information and knowledge is not only confusing on the account of multiple synonyms and revised taxonomy, but also generally deficient from the perspective of current distribution of species, threats faced, and the overall status. In view of this, the foremost and challenging requirement was to prepare an inventory of selected/ prioritized FGR species having the updated current nomenclature along with the concerned authority, synonyms, uses, and threats.

Based on the extensive review of existing information on floristics and also the wider consultative process, the valuable information on current botanical nomenclature with relevant authority and local/common names of 250 FGR species along with an insight on family, habit, prevalent synonyms in Uttarakhand, uses and threats were generated and are summarized in Table 3.4.

Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
1.	Abies pindrow (Royle ex D. Don) Royle	Pinaceae	Tree	Morinda, Low level silver Fir	Synonyms: Abies himalayensis Lavallée; Abies webbiana var. pindrow (Royle ex D. Don) Brandis Threat: Anthropological pressure (Developmental activities) Uses: Timber
2.	Abies spectabilis (D. Don) Mirb.	Pinaceae	Tree	High level Silver Fir	Synonyms: Abies spectabilis (D. Don) Spach; Abies webbiana (Wall. ex D. Don) Lindl.; Pinus spectabilis D. Don Threat: Anthropological pressure (Developmental activities) Uses: Timber.
3.	Acacia catechu (Linnaeus f.) Willdenow	Mimocac- eae	Tree	Babul, Kikar	Synonym: Senegalia catechu (L. f.) P. J. H. Hurter & Mabb. Threat: Over exploitation for Cutch and Kattha Uses: Source of Cutch.
4.	Acacia pseudo -eburnea Dunn*	Mimosac- eae	Tree		Synonyms: Acacia eburnean, Willd. Threat: The population inside the PAs are well preserved but those outside PAs and on road sides are vulnerable to destruction by road widening. Uses: Fuelwood.
5.	<i>Acer caesium</i> Wall. ex Brandis	Aceraceae	Tree	Kainju, Bara Kainju, Kainjal	Synonym: Acer luteolum Borbás Threat: Anthropological pressure (used by Buddhist for making cup) Uses: Wooden utensils by Buddhist.
6.	Acer oblongum Wall. ex DC.	Aceraceae	Tree	Pangoi, Paranga, Kirmola, Kirmoli	Synonym: Acer oblongifolium Hort. ex Dippel Threat: Anthropological pressure (used by Buddhist for making cup) Uses: Timber.
7.	Acer sterculia- ceum Wall.	Aceraceae	Tree	Kainchli, Kabasi, Dudh, Kainju	Synonyms: Acer villosum Wall.; Acer villosum f. sterculiaceum (Wall.) Schwerin Threat: Anthropological pressure (used by Buddhist for making cup) Uses: Wooden utensils by Buddhist.
8.	Acronychia pedunculata (L.) Miq	Rutaceae	Tree		Synonym: Acronychia laurifolia Blume Threat: Anthropological pressure (Widening of roads) Uses: Charcoal preferred by goldsmiths.

Table 3.4
Threats and
Uses of
Selected FGR
Species



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
9.	Actinidia callosa Lindl. *	Actinidi- aceae	Woody Climber	Himalayan Kiwi Vine	Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Fruit acidic and edible.
10.	Aegle marmelos (L.) Corrêa	Rutaceae	Tree	Bel, Bili, Bael, Vilva	Synonym: Crateva marmelos L. Threat: Anthropological pressure (Developmental activities) Uses: Sacred tree, fruit edible, Medicinal, Leaves in Hindu Worship.
11.	Aesculus indica (Wall. ex Camb.) Hook.	Hippocast anaceae	- Tree	Pangar, Bankhor, kandur,	Synonym: Pavia indica Wall. ex Cambess. Threat: Anthropological pressure (Widening of roads, land slide, climate change) Uses: Carpentary work.
12.	Alangium salviifolium (L.f.) Wangerin	Alangia- ceae	Tree	Akola, Ankora, Bismar	Synonym: Alangium lamarckii Thwaites Threat: Anthropological pressure (Widening of roads) Uses: Agricultural implements and medicinal.
13.	Albizia chinensis (Osbeck) Merrill	Mimoc- aceae	Tree	Siran	Synonym: Acacia stipulata DC.; Albizia stipulata (D.C Boivin) Threat: Anthropological pressure (Widening of roads) Uses: Cultivated for shade in tea and coffee plantations.
14.	<i>Albizia julibrissin</i> Durazzini	Mimoc- aceae	Tree	Bhondir, Kurmura	Synonym: Acacia julibrissin (Durazz.) Willd. Threat: Anthropological pressure (Widening of roads) Uses: Medicinal, ornamental.
15.	Albizia lebbeck (Linnaeus) Bentham	Mimoc- aceae	Tree	Kala Siris, Sirsa	Synonyms: Acacia lebbeck (L.) Willd.; Mimosa lebbek L. Threat: Anthropological pressure (Developmental activities) Uses: Decorative timber.
16.	Albizia odoratissima Benth	Mimoc- aceae	Tree	Kali Siris	Synonym: Acacia odoratissima (L.f.) Willd. Threat: Anthropological pressure (Developmental activities) Uses: Timber. Cultivated for shade in tea gardens.
17.	Albizia procera (Roxb.) Benth.	Mimoc- aceae	Tree	Safed Siris, Karha, Karhai	Synonym: Acacia procera (Roxb.) Willd. Threat: Anthropological pressure (Developmental activities) Uses: Commonly used for shade in tea gardens.
18.	Alnus nepalensis D. Don	Cupulif- erae	Tree	Kunis, Puzala	Synonym: Clethropsis nepalensis (D. Don) Spach. Threat: Anthropological pressure (Developmental activities) Uses: Reclaimation of degraded lands.
19.	Alnus nitida (Spach) Endl.	Cupulif- erae	Tree	Utis, Kunis	Synonym: Clethropsis nitida Spach. Threat: Anthropological pressure (Developmental activities) Uses: Carpentary work.
20.	Alstonia scholaris (Linnaeus) R. Brown	Apocyna- ceae	Tree	Saptaparni, Satian, Chhatian	Synonym: Pala scholaris (Linnaeus) Roberty. Threat: Anthropological pressure (Developmental activities) Uses: Avenue tree.
21.	Anogeissus latifolia (Roxb. ex DC.) Wall. ex Guill. & Perr.	Combre- taceae	Tree	Bakli, Bankli	Synonym: Conocarpus latifolius Roxb. ex DC Threat: Anthropological pressure (lopping for fodder) Uses: Excellent fodder.

Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
22.	Aristolochia punjabensis Lace*	Aristoloc- hiaceae	Woody Climber		Threat: Lopping of branches for lichen collection Uses: Medicinal, host of Golden bird wing butterfly.
23.	Asparagus adscendens Roxb.	Liliaceae	Shrub	Hazar-muli, Jhirna	Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.
24.	Azadirachta indica A. Juss	Meliaceae	Tree	Nim, Neem	Synonyms: Melia azadirachta L.; Melia indica (A. Juss.) Brandis Threat: Anthropological pressure (over exploitation for medicine). Uses: Medicinal.
25.	Bauhinia purpurea Linn.	Caesalpi- naceae	Tree	Guiral, Khairwal, Khairwal papri	Threat: Anthropological pressure (lopping for fodder). Uses: Ornamental.
26.	Bauhinia racemosa Lamarck	Caesalpi- naceae	Tree	Jhinjhora, Jhanjhora	Synonym: Piliostigma racemosum (Lamarck) Bentham Threat: Anthropological pressure (Developmental activities). Uses: Fodder.
27.	Bauhinia variegata Linn.	Caesalpi naceae	Tree	Kachnar	Threat: Anthropological pressure (over exploitation for vegetables). Uses: Flower buds consumed as vegetable.
28.	<i>Berberis rawatii</i> U.L. Tiwari and B.S. Adhikari*	Berberid- aceae	Shrub		Threat: Anthropological pressure (over expoitation and Developmental activities). Uses: Medicinal.
29.	<i>Berberis asiatica</i> Roxb. ex DC.	Berberid- aceae	Shrub	Kashmoi, Kingora	Synonym: Berberis aristata sensu Hook.f. & Thomson, Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.
30.	<i>Berberis chitria</i> BuchHam. ex Lindl.	Berberid- aceae	Shrub	Kingora	Synonym: Berberis chitria var. occidentalis Ahrendt Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.
31.	<i>Berberis</i> <i>kumaonensis</i> C.K. Schneid.*	Berberid- -aceae	Shrub		Threat: Anthropological pressure (Over exploitation and developmental activities) Uses: Medicinal.
32.	<i>Berberis</i> <i>lambertii</i> Parker*	Berberid- aceae	Shrub		Threat: Anthropological pressure (Over expoitation and developmental activities) Uses: Medicinal.
33.	<i>Berberis lycium</i> Royle	Berberid- aceae	Shrub	Kashmoi, Kingora	Synonym: Berberis angustifolia Roxb. Threat: Anthropological pressure (Over exploitation) Uses: Medicinal, Yellow dye.
34.	<i>Berberis</i> <i>osmastonii</i> Dunn*	Berberid- aceae	Shrub		Threat: Anthropological pressure (Over expoitation and developmental activities) Uses: Medicinal.
35.	Berberis pseudumbellata R. Parker*	Berberid- aceae	Shrub		Threat: Anthropological pressure (Over expoitation and developmental activities) Uses: Medicinal.
36.	Berchemia floribunda Wall.*	Rhamna- ceae	Woody Climber	Kouloi	Threat: Genetic aberration, Anthropological pressure (Developmental activities and Forest Fire) Uses: Young leaves substitute for tea, medicinal.



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37.	Berchemia lineata DC. *	Rhamna- ceae	Woody Climber	Angari	Synonyms: Rhamnus lineata L., Ziziphus lineata Willd. Threat: Genetic aberration, Anthropological pressure (Developmental activities) Uses: Fruit edible, medicinal.
38.	Betula alnoides BuchHam. ex D. Don	Betula- ceae	Tree	Kath Bhuj	Synonym: Betula acuminata Wall. Threat: Anthropological pressure (Development activities) Uses: Exceptionally good plywood for tea-chests.
39.	Betula utilis D. Don	Betulac- eae	Tree	Bhojpatra, Bhuj	Synonym: Betula bhojpattra var. latifolia Regel Threat: Anthropological pressure (Ectourism & Climate change) Uses: Bark is papery ancient manuscripts were written on the sheets of this bark.
40.	<i>Bischofia</i> <i>javanica</i> Blume	Euphorb- iaceae	Tree	Paniala, Kot Semla, Kaen, Bhillar	Synonym: Bischofia javanica var. lanceolata Müll.Arg. Threat: Anthropological pressure (Climate change) Uses: Preferred for boats and dugouts.
41.	Boehmeria penduliflora Wedd. ex D.G. Long*	Urticaceae	Shrub	Pahari Kikar	Synonym: Boehmeria densiflora var. penduliflora (Wedd. ex D.G. Long) Acharya & Yonek. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Fiber
42.	Boehmeria rugulosa Wedd.	Urticaceae	Tree	Genthi, Genti	Synonym: Pouzolzia rugulosa (Wedd.) Acharya & Kravtsova Threat: Anthropological pressure (Climate change) Uses: Wooden utensils (preferered for setting curd).
43.	Bombax ceiba Linn.	Bombaca- ceae	Tree	Simal, Semal	Synonym: Bombax ceiba Burm.f.; Bombax malabaricum DC. Threat: Anthropological pressure (Fruit and seed expoiltation for vegetable and cotton) Uses: Plywood and matchsticks.
44.	Boswellia serrata Roxb. ex Colebr.	Bursera - ceae	Tree	Salai, Salar,	Synonym: Boswellia glabra Roxb. Threat: Anthropological pressure (Over expoitation for medicine) Uses: Medicinal.
45.	Brassaiopsis aculeata (Buch. - Ham. ex D. Don) Seem. *	Araliaceae	Shrub		Synonym: Hedera aculeata BuchHam. ex D. Don Threat: Threat: Genetic aberration, Anthropological pressure (Habitat destruction especially due to landslides) Uses: Fodder.
46.	<i>Bridelia retusa</i> (Linn.) A. Juss.	Euphorb- iaceae	Tree	Ekdania, Gondni, Gaya, Khaja	Synonym: <i>Bridelia crenulata</i> Roxb. Threat: Anthropological pressure Uses: Gum used as medicine.
47.	Buchanania cochinchinensis (Lour.) M.R. Almeida	Anacardi- aceae	Tree	Piyal, Kath Bhilawa	Synonym: Buchanania lanzan Spreng. Threat: Anthropological pressure (Developmental activities) Uses: Seeds (Chironji) used in confectionery.
48.	Butea monosperma (Lam.) Taub.	Fabaceae	Tree	Dhak, Palas	Synonym: Butea frondosa Willd. Threat: Anthropological pressure (over expoitation for leaves)

Uses: Dye from flowers.

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49.	Buxus wallichiana Baill.,	Buxaceae	Tree	Papri, Sansadu, Chikri	Threat: Anthropological pressure (Developmental activities) Uses: Jewellery boxes and comb.
50.	Calamus tenuis Roxb.	Arecaceae	Woody Climber	Bet, Bent	Synonym: Calamus royleanus Griff. Threat: Anthropological pressure (over exploitation) Uses: Handicrafts and cane sticks.
51.	Callicarpa macrophylla Vahl	Verbena- ceae	Shrub	Daia	Synonym: Callicarpa roxburghii Wall. ex Walp. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
52.	Calotropis gigantea (L.) W.T. Aiton	Asclepi- adaceae	Shrub	Madar, Safed Ak	Synonym: Asclepias gigantea L. Threat: Anthropological pressure Uses: Medicinal.
53.	Calotropis procera (Aiton) W.T. Aiton	Asclepi- adaceae	Shrub	Madar, Ak	Synonym: Asclepias procera Aiton Threat: Anthropological Pressure Uses: Medicinal.
54.	Caragana gerardiana Benth.	Fabaceae	Shrub	Kathur, Kanta	Synonym: Caragana spinosissima Benth., Threat: Anthropological pressure (Developmental activities) Uses: Impenetrable hedge plantation.
55.	Caragana sukiensis C.K. Schneid.*	Fabaceae	Shrub		Synonym: Caragana nepalensis Kitam. Threat: Genetic aberration, Anthropological pressure Developmental activities) Uses: Fodder, soil binder.
56.	Carallia brachiata (Lour.) Merr. *	Rhizopho- raceae	Tree	Freshwater Mangrove	Synonym: Carallia cerisopsitolia Miq. Threat: Genetic aberration, Anthropological pressure (Developmental activities resulting in shrinkage of swamps). Uses: Small farm implements, quality fuel and charcoal.
57.	Careya arborea Roxb.	Lecythid- aceae	Tree	Kumbhi, Kumbi	Synonym: Barringtonia arborea (Roxb.) E Muell. Threat: Anthropological pressure (Developmentals activities) Uses: Agricultural implement.
58.	Carpinus viminea Wall. ex Lindl.	Betulaceae	Tree	Shinroi, Shangri, Chamkharik	Synonym: Carpinus davidii (Franch.) C.K. Schneid. Threat: Anthropological pressure (Developmental activities) Uses: Timber.
59.	<i>Cassia fistula</i> Linn	Caesalpin- aceae	Tree	Amaltas, Kirala, Sinara	Synonym: Cassia fistuloides Collad. Threat: Anthropological pressure (Developmental activities) Uses: Ornamental
60.	Catamixis baccharoides Thomson*	Asteraceae	Shrub	Catamixis	Threat: Genetic aberration, Anthropological pressure (Developmental activities) Uses: Not known, possibly because of critically low population in the region.
61.	Catunaregam spinosa (Thunb.) Tirveng.	Rubiaceae	Shrub	Maindal, Mainphal, Madana	Synonyms: Randia spinosa (Thunb.) Blume; Catunaregam dumetorum (Retz.) Tirveng., Randia dumetorum (Retz.) Lam Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
62.	Cedrus deodara (Roxb. ex Lamb.) G. Don,	Pinaceae	Tree	Deodar, Devadaru, Kelon	Synonym: Abies deodara (Roxb. ex Lamb.) Lindl., Cedrus indica Chambray. Threat: Anthropological pressure (Developmental activities) Uses: Timber and resin.



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63.	Celastrus paniculatus Willd.	Celastra- ceae	Woody Climber	Malkangni	Threat: Anthropological pressure (Exploitation for medicine) Uses: Medicinal.
64.	Celtis australis L.	Ulmaceae	Tree	Kharak-chena	Synonym: Celtis australis var. eriocarpa (Decne.) Hook. f. Threat: Anthropological pressure (Over expoitation for fodder) Uses: Fodder
65.	Celtis tetrandra Roxb.	Ulmaceae	Tree		Synonym: Celtis roxburghii Planch. Threat: Anthropological pressure (Over expoitation for fodder) Uses: Fodder
66.	Ceriscoides turgida (Roxb.) Tirveng.*	Rubiaceae	Tree	Thanela	Synonym: Gardenia turgida Roxb. Threat: Genetic aberration, Anthropological pressure (Developmental activities) Uses: Medicinal, fuelwood.
67.	Chonemorpha fragrans (Moon) Alston	Apocyn- aceae	Woody Climber		Synonym: Chonemorpha macrophylla (Roxb.) G. Don Threat: Anthropological pressure (Developmental activities) Uses: Fibre.
68.	Cinnamomum glanduliferum (Wall.) Meisn. *	Lauraceae	Tree	Nepal camphor	Synonym: Camphora glandulifera (Wall.) Nees Threat: Genetic aberration, Anthropological pressure (Developmental activities) Uses: Medicinal.
69.	Cinnamomum tamala (Buch. -Ham.) T. Nees & Eberm.	Lauraceae	Tree	Dalchini, Gur-andra	Synonym: Persea tamala Spreng. Threat: Anthropologial pressure (Over expoitation) Uses: Leaves and bark as spice.
70.	Clematis gouriana Roxb. ex DC.	Ranunc- ulaceae	Woody Climber	Bel kum, Bel kungu	Threat: Anthropological Pressure (Developmental activities) Uses: Medicinal.
71.	Clematis montana Buch. -Ham. exDC.	Ranunc- ulaceae	Woody Climber	Kaunia bali,	Synonym: Clematis montana var. grandiflora Hook. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
72.	Cleyera japonica Thunb. *	Pentaphy- lacaceae	Shrub	Japanese cleyera	Synonym: Cleyera ochnacea sensu Dyer Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Planted in gardens.
73.	Cochlospermum religiosum (L.) Alston, Handb. *	Bixaceae	Tree	Gejra, Arlu	Synonym: Cochlospermum gossypium DC. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Floss for stuffing pillows, gum medicinal.
74.	Cordia dichotoma G. Forst.	Boragina- ceae	Tree	Lassora, Lassura	Synonym: Cordia indica Lam. Threat: Anthropological pressure (Developmental activities) Uses: Ripe fruits cooked as vegetable. Glue from fruit.
75.	Comus capitata Wall. ex Roxb.	Cappara- ceae	Tree	Thanboi, Bhamora	Synonyms: Benthamia capitata (Wall.) Nakai; Benthamidia capitata (Wall.) H. Hara Threat: Anthropological pressure (Developmental activities) Uses: Fruits fevoured by bear. Ornamental value for gardens.



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76.	Cornus macrophylla Wall.	Coronac- eae	Tree		Synonym: Swida macrophylla (Wall.) Sojak Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
77.	Corylus jacquemontii Decne.	Betulac- eae	Tree	Bhutia Badam	Synonym: Corylus colurna var. lacera A. DC. Threat: Anthropological pressure (Over exploitation for seed) Uses: Seed kernels eaten by locals.
78.	Cotoneaster frigidus Wall. *	Rosaceae	Shrub		Synonyms: Cotoneaster affinis Auct., Cotoneaster himalayensis Hort. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Decorative garden shrub.
79.	Crateva adansonii subsp. odora (Buch Ham.) Jacobs	Cappara- ceae	Tree		Synonym: Crateva odora BuchHam. Threat: Anthropologial pressure (Developmental activities) Uses: Medicinal.
80.	<i>Cryptolepis</i> <i>dubia</i> (Burm.f.) M.R. Almeida	Asclepia- daceae	Woody Climber	Dudhi, Medha- singhi, Karanta	Synonym: Cryptolepis buchananii Roem, & Schult. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
81.	Cupressus torulosa D. Don	Cupress- aceae	Tree	Leuri, Leauri, Devidiar	Synonym: Cupressus sempervirens var. indica Parl. Threat: Anthropological pressure (Developmental activities) Uses: Afforestation purpose.
82.	Cyathea spinulosa Wall. ex Hook.*	Cyathea- ceae	Shrub	Tree Fern	Synonym: Cyathea taiwaniana Nakai Threat: Anthropological pressure (Developmental acivities). Uses: Ornamental, medicinal, stem rich in starch.
83.	Dalbergia lanceolaria L.f.	Fabaceae	Tree		Synonym: Dalbergia arborea sensu B. Heyne ex Roth. Threat: Anthropological pressure (Development activities) Uses: Agriculture implements.
84.	<i>Dalbergia</i> <i>latifolia</i> Roxb.	Fabaceae	Tree	Black Rosewood, Bombay blackwood	Synonym: Dalbergia emarginata Roxb. Threat: Anthropological pressure (Tourism, Developmental activities) Uses: Timber.
85.	<i>Dalbergia sissoo</i> Roxb.	Fabaceae	Tree	Shisham, Sissoo	Synonym: Pterocarpus sissoo (Roxb. ex DC.) Wight & Arn Threat: Anthropological pressure (Development activities) Uses: Timber.
86.	<i>Daphniphyllum</i> <i>himalayense</i> (Benth.) Müll	Daphnip- hyllaceae	Tree	Ratendu	Synonym: Goughia himalayensis Benth Threat: Anthropological pressure (Development activities) Uses: Medicinal.
87.	Datisca cannabina L. *	Datisca- ceae	Shrub	False hemp	Synonym: Datisca nepalensis D. Don Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
88.	Debregeasia saeneb (Forssk.) Hepper & J.R.I.	Urticaceae	Shrub	Tushiari, Sansaru Siar, Sinar	Synonym: Debregeasia hypoleuca (Steud.) Wedd. Threat: Anthropological pressure (Over exploitation for fruit) Uses: Fuel, bark produces strong fibre.
89.	<i>Dillenia</i> pentagyna Roxb.	Dilleniac- eae	Tree	Karmal, Dog Teak	Synonym: <i>Dillenia augusta</i> Roxb. Threat: Anthropological pressure (Fodder) Uses: Fruits edible.



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				Name	
90.	Diospyros melanoxylon Roxb var. tupru (BuchHam.) V. Singh	Ebenac- eae	Tree	Pinna	Synonyms: Diospyros exsculpta Buch Ham.; Diospyros tomentosa Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Leaves used for preparation of biri smoking.
91.	<i>Diospyros</i> montana C.B. Clarke	Ebenac- eae	Tree	Tendu	Synonym: <i>Diospyros kanjilalii</i> Duthie Threat: Anthropological pressure (Developmental activities) Uses: Agriculture implements.
92.	Diploknema butyracea (Roxb.) H.J. Lam.	Sapotac- eae	Tree	Chiura, Phalwana, Phulel, Phuloa	Synonym: Bassia butyracea Roxb. Threat: Anthropological pressure (Over exploitation of seeda for Chura Ghee) Uses: Important source of edible oil extracted from seeds.
93.	Dodecadenia grandiflora Nees*	Lauraceae	Tree	Dodecadenia	Synonym: Tetranthera grandiflora Wall. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Agricultural tools.
94.	Drypetes assamica (Hook.f.) Pax & K. Hoffm*	Euphorbi- aceae	Tree	Khadbehula	Synonym: Cyclostemon assamicus Hook.f. Threat: Genetic aberration, Anthropological Pressure (Developmental activities resulting shrinkage of swamps) Uses: Fodder, fruit edible.
95.	Dysoxylum gotadhora (BuchHam.) Mabb.*	Meliaceae	Tree	Cup-Calyx, White Ceda	Synonym: Dysoxylum binectariferum (Roxb.) Hook, f. ex Bedd. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Furniture and cart making.
96.	Elaeagnus	Elaeagna-	Shrub	Loharu	Synonym: Elaeagnus latifolia Bedd.
00.	conferta Roxb.	ceae	Sinus	Honar u	Threat: Anthropological pressure (Over exploittaion for fruit) Uses: Acid fruit eaten by locals.
97.	Elaeodendron glaucum (Rottb.) Pers	Celastra- ceae	Tree	Dhebri, jangela, Jangel, paniala	Synonym: Cassine glauca (Rottb.) Kuntze Threat: Anthropological pressure (Development activities) Uses: Agriculture implements.
98.	Engelhardtia spicata var. integra (Kurz) W.E. Manning ex Steenis	Juglanda- ceae	Tree	Mowa, Mauwa	Synonym: Engelhardtia colebrookiana Lindl. Threat: Anthropological pressure (lopping for fodder) Uses: Fodder.
99.	<i>Ephedra</i> <i>gerardiana</i> Wall. ex Stapf	Ephedra- ceae	Shrub	Tut-gandha	Threat: Anthropological pressure (Development activities) Uses: Medicinal.
100.	Erythrina suberosa Roxb.	Fabaceae	Tree	Dhaul, Dhal, Madar	Synonym: Erythrina sublobata Roxb. Threat: Anthropological pressure (lopping for fodder) Uses: Ornamental.
101.	Falconeria insignis Royle	Euphorb- iaceae	Tree	Khinna, Khindra, Khinni, Khirni	Synonym: Sapium insigne (Royle) Trimen Threat: Anthropological pressure (Developmental activities) Uses: Often lopped for medium quality fodder.
102.	Ficus auriculata Lour.	Moraceae	Tree	Tirmal, Tirboi	Synonym: Ficus macrophylla Roxb. & Buch Ham. ex Sm Threat: Anthropological pressure (lopping for fodder and exploitation for fruit) Uses: Fruits cooked as vegetable.



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103.	Ficus benghalensis L.	Moraceae	Tree	Bar, Bargat	Synonym: Ficus indica sensu L. Threat: Anthropological pressure (Development activities) Uses: Sacred tree.
104.	Ficus glaberrima Blume*	Moraceae	Tree		Synonym: Urostigma glaberrimum (Blume) Miq Threat: Genetic aberration, Anthropological pressure (Developmental activities resulting shrinkage of swamps) Uses: Fruits eaten raw, inner bark produce fibre.
105.	Ficus microcarpa L.f.	Moraceae	Tree		Synonyms: Ficus retusa var. crassifolia W.C. Shieh, Ficus dilatata Miq. Threat: Anthropological pressure (Development activities) Uses: Occasionally used as pot plant.
106.	Ficus neriifolia J.E. Sm.	Moraceae	Tree	Dudhla, Dudhoi, Parphuta	Synonyms: Ficus neriifolia var. nemoralis (Wall. ex Miq.) Corner, Ficus nemoralis Wall. ex Miq. Threat: Anthropological pressure (lopping for fodder) Uses: Excellent fodder of high altitude.
107.	Ficus pomifera Wall. ex King*		Moraceae	Tree	Threat: Anthropological psressure (Developmental activities resulting shrinkage of swamps) Uses: Medicinal.
108.	Ficus racemosa L.	Moraceae	Tree	Gular	Synonyms: Ficus glomerata Roxb; Ficus goolerea Roxb. Threat: Anthropological pressure (lopping for fodder) Uses: Fruit use for wildlife
109.	Ficus rumphii Blume	Moraceae	Tree	Pilkhan, Khabar, Pilkhoi	Synonym: Ficus cordifolia Roxb. Threat: Anthropological Pressure (Development Activities) Uses: The twigs excellent fodder for elephants.
110.	Ficus semicordata BuchHam. ex J.E. Sm.	Moraceae	Tree	Khain, Kheina, Jarhphali	Synonym: Ficus cunia Buch Ham. ex Roxb. Threat: Anthropological pressure (lopping for fodder) Uses: Edible gum extracted from stem.
111.	Ficus virens Aiton	Moraceae	Tree	Khabar, Duthli, Pilkhoi, Pakhar, Kobra, Pilkharu	Synonyms: Ficus infectoria Roxb., Ficus lacor Rehder Threat: Anthropological pressure (lopping for fodder) Uses: Important shade tree and good fodder for goats.
112.	Flacourtia jangomas (Lour.) Raeusch.	Flacourt- iaceae	Tree	Sialu, Katari, Kandhura, Phalama	Synonym: Flacourtia cataphracta Roxb. ex Willd. Threat: Anthropological Pressure (Lopping for fodder) Uses: Agriculture implements, acid fruits pickled.
113.	Fraxinus micrantha Lingelsh.	Oleaceae	Tree		Threat: Anthropological pressure (Lopping for fodder) Uses: Timber.
114.	Fraxinus xanthoxyloides* (Wall. ex G. Don) A. DC.	Oleaceae	Tree		Synonym: Ornus xanthoxyloides Wall. ex G. Don Threat: Genetic aberration, Anthropological pressure (over exploitation of leaves). Uses: Tool-handles, fodder.



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115.	Garuga pinnata Roxb.	Burserac- eae	Tree	Name Kharpat	Synonym: Kunthia pinnata (Roxb.) Kuntze Threat: Anthropological pressure (Development Activities) Uses: Rarely used for fodder.
116.	Glochidion ellipticum Wight*	Phyllanth- aceae		Tree	Synonyms: Phyllanthus assamicus Müll. Arg., Glochidion malabaricum (Müll. Arg.) Bedd., Glochidion assamicum (Müll. Arg.) Hook.f. Threat: Genetic aberration, Anthropological pressure (Developmental activities resulting shrinkage of swamps) Uses: Medicinal.
117.	<i>Gmelina arborea</i> Roxb. ex Sm.	Verbenac- eae	Tree	Gamhar, Kumhar, Kahmhar	Synonym: Gmelina oblongifolia Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Important timber.
118.	Grewia asiatica L.	Tiliaceae	Tree	Phalsa, Phalsa- Dhaman	Synonym: Grewia hainesiana Hole Threat: Anthropological pressure (Lopping for fodder and extraction of fruit) Uses: Edible fruits
119.	<i>Grewia optiva</i> J.R. Drumm. ex Burret	Tiliaceae	Tree	Bhimal, Bewal, Biul, Biur	Threat: Anthropological pressure (Lopping for fodder and extraction of fiber from bark) Uses: Fibre, fodder and fuelwood.
120.	Haldina cordifolia (Roxb.) Ridsdale	Rubiaceae	Tree	Haldu	Synonym: Adina cordifolia (Roxb.) J. D. Hooker ex B. D. Jackson Threat: Anthropological pressure (Developmental activities) Uses: Timber.
121.	Helicteres isora L.	Sterculi- aceae	Shrub	Maror-phal, Kapasi	Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.
122.	Heteropanax fragrans (Roxb. ex DC.) Seem.*	Araliac- eae	Tree		Synonym: Panax fragrans Roxb. ex DC Threat: Genetic aberration, Anthropological pressure (Developmental activities) Uses: Ornamental.
123.	Hippophae salicifolia D. Don.	Elaeagn- aceae	Shrub	Dhurchuk, Tarwa, Chuma	Synonym: Hippophae rhamnoides subsp. salicifolia (D. Don) Servettaz Threat: Anthropological pressure (Developmental activities) Uses: Fuelwood, charcoal.
124.	Hiptage benghalensis (L.) Kurz	Malpeghi- aceae	Woody Climber	Mudh Malti, Madhavilata	Synonym: Banisteria benghalensis L. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal, insecticidal.
125.	Holboellia latifolia Wall.	Lardiza- balaceae	Woody Climber	Gophla, Jungli sharifa	Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
126.	Holoptelea integrifolia (Roxb.) Planch.	Ulmaceae	Tree	Papri, Kala Papri, Banchilla	Synonym: Ulmus integrifolia Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
127.	<i>Hovenia dulcis</i> Thunb.	Rhamnac- eae	Tree		Threat: Anthropological pressure (Developmental activities) Uses: Furniture making.
128.	Hymenodictyon orixense (Roxb.) Mabb.	Rubiaceae	Tree	Bhaulan, Kukurkat	Synonym: Hymenodictyon excelsum (Roxb.) Wall. Threat: Anthropological pressure (Developmental activities) Uses: Agriculture implements and cheaper grades of furniture.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
129.	<i>Ilex fragilis</i> J. D. Hooker*	Aquifoli- aceae	Tree		Synonym: <i>Ilex fragilis</i> f. kingii Loesener Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Potential ornamental species.
130.	Ilex pseudo- odorata Loes*	Aquifoli- aceae	Tree		Synonym: Ilex odorata Hook.f. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Fodder.
131.	<i>Indigofera</i> <i>cassioides</i> Rottler ex DC.	Fabaceae	Shrub	Sakira	Synonym: Indigofera pulchella Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
132.	Indopiptadenia oudhensis (Brandis) Brenan*	Mimosac- eae	Tree		Synonym: Piptadenia oudhensis Brandis Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Fodder, fuel.
133.	Juglans regia L.	Jugland- aceae	Tree	Akhrot, Akhor, Okhar	Threat: Anthropological pressure (Over exploitation for fruit) Uses: Best for furniture and carving.
134.	Juniperus polycarpos C. Koch	Cupress- aceae	Tree	Dhup, Himalayan Pencil Cidar	Synonym: Juniperus macropoda Boiss Threat: Anthropological pressure (Developmental activities, over expoitation for leaves) Uses: Medicinal.
135.	Justicia adhatoda L.	Acantha- ceae	Shrub	Bansa, Arusa, Vasica	Synonym: Adhatoda vasica Nees. Threat: Anthropological pressure (Over exploitation for medicine) Uses: Medicinal.
136.	Kydia calycina Roxb.	Malvac- eae	Tree	Pula, Pulu, Puli	Synonym: Kydia roxburghiana Wight Threat: Anthropological pressure (Lopping for fodder) Uses: Agricultural implements, light packing-cases, fodder.
137.	Lagerstroemia parviflora Roxb.	Lythraceae	Tree	Dhaura, Dhauri, Adhuari	Threat: Anthropological pressure (Developmental activities) Uses: Furniture making.
138.	Lannea coromandelica (Houtt.) Merr. J	Anacard- iaceae	Tree	Jhingham, Jhinghini	Synonym: Dialium coromandelicum Houtt. Threat: Anthropological pressure (Developmental activities) Uses: Excellent fodder.
139.	Litsea glutinosa (Lour.) C.B. Rob.	Lauraceae	Tree	Chandna, Maida - lakri	Synonym: Litsea glutinosa var. glutinosa Threat: Anthropological pressure (over expoitation for medicinal value) Uses: Agricultural implements, fiber.
140.	Litsea monopetala (Roxb.) Pers.	Lauraceae	Tree	Karka, Karkawa	Synonyms: Tetranthera monopetala Roxb., Litsea polyantha Juss. Threat: Anthropological pressure (Lopping for fodder and development activities) Uses: Fodder, rearing Muga silkworms in Assam.
141.	Macaranga indica Wight*	Euphorbi- aceae	Tree	Indian Macaranga	Synonym: Tanarius indicus (Wight) Kuntz Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
142.	<i>Macaranga</i> <i>pustulata</i> King ex J. D. Hooker	Euphorbi- aceae	Tree		Synonym: Macaranga denticulata (Blume) Müller Threat: Anthropological pressure (Developmental activities). Uses: Fast growing species thus, potential use in reforestation projects.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
143.	Machilus duthiei Kingex Hook.f.	Lauraceae	Tree	Kawala Bhojo	Synonym: Persea duthiei (King ex Hook.f.) Kosterm. Threat: Anthropological pressure (Developmental activities) Uses: Fuelwood.
144.	Machilus gamblei King ex Hook.f	Lauraceae	Tree		Synonyms: Persea gamblei (King ex Hook.f.) Kosterm., Machilus bombycina King ex Hook.f. Threat: Anthropological pressure (Developmentala activities) Uses: Tea-boxes and other packing-cases.
145.	Machilus odoratissimus Nees in Wall.	Lauraceae	Tree	Kawala, Kaula, Kaulu	Synonym: Persea odoratissima (Nees) Kosterm. Threat: Anthropological pressure (Developmental activities) Uses: Timber.
146.	Macropanax dispermus (Blume) Kuntze*	Araliaceae	Tree		Synonym: Macropanax oreophilus Miq. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
147.	Madhuca longifolia (J. Koenig ex L.) J.F. Macbr. var. latifolia (Roxb.) A. Chev	Sapotac- eae	Tree	Mauwa, Mahua, Mohwa	Synonyms: Madhuca latifolia (Roxb.) J.F. Macbr., Madhuca indica J.F. Gmel Threat: Anthropological pressure (Lopping for fodder) Uses: Flowers in brewing beverages, medicinal.
148.	Magnolia kisopa (BuchHam. ex DC.) Figlar*	Magnoli- aceae	Tree	Chaam, Chaur	Synonym: Michelia kisopa BuchHam. ex DC. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Ornamental.
149.	Mahonia jaunsarensis Ahrendt*	Berberid- aceae	Shrub	Jaunsar Barberry	Synonym: Berberis jaunsarensis (Ahrendt) Laferr. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
150.	Malus baccata (L.) Borkh.*	Rosaceae	Tree		Synonym: Pyrus baccata L. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Preferred apple rootstock, fruits edible.
151	Mangifera indica L.	Anacardi- aceae	Tree	Am, Ambi	Synonym: Mangifera austroyunnanensis Hu Threat: Anthropological pressure (Developmental activities) Uses: Sacred tree, chiefly valued for fruit.
152.	Marsdenia griffithii Hook. f. *	Apocyna- ceae	Woody Climber		Synonym: Marsdenia lucida Hook.f. & Thomson Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
153.	Maytenus rufa (Wall.) Cufod.*	Celastra- ceae	Shrub		Synonym: Celastrus rufus Wall. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
154.	Meizotropis pellita (Hook.f. ex Prain) Sanjappa*	Fabac- eae	Woody Climber	Patwadangar	Synonym: Butea pellita Hook.f. ex Prain Threat: Genetic aberration, Anthropological pressure (habitat destruction due to forest fire).

Uses: Medicinal.

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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
155.	Melia azedarach L.	Meliace- ae	Tree Deknoi	Dek, Bakain,	Synonym: Melia azedarach var. glabrior C. DC. Threat: Anthropological pressure (Lopping for fodder) Uses: Fodder
156.	Miliusa velutina (Dunal) Hook.f. & Thoms.	Annonac- eae	Tree		Synonym: <i>Uvaria velutina</i> Dunal Threat: Anthropological pressure (Lopping for fodder) Uses: Agriculture implements.
157.	Mitragyna parvifolia (Roxb.) Korth:	Rubiac- eae	Tree	Kaem, Phaldu	Synonym: Nauclea parvifolia Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Agricultural implements, combs, carved articles.
158.	Moringa oleifera Lam.	Moringa- ceae	Tree	Sohjna, Sainjna, Sondna	Synonym: Moringa pterygosperma Gaertn Threat: Anthropological pressure (Lopping for fruit used in curry) Uses: Medicinal, pods in soups and stew.
159.	Myrica esculenta BuchHam. ex D. Don	Myricac- eae	Tree	Kaiphal, Kaphal	Synonym: Myrica nagi sensu Hook.f.; Myrica esculenta (BuchHam. ex D. Don) I.M. Turner Threat: Anthropological pressure (Over extraction of fruit) Uses: Fruits eaten raw and make refreshing sherbet (squash).
160.	Neolitsea cuipala (D. Don) Kosterm.	Laurac- eae	Tree		Synonym: Litsea languinosa (Nees) Nees Threat: Anthropological pressure (Developmental activities) Uses: Medicinal use in chinese pharmacopoeia
161.	Neolitsea pallens (D. Don) Momiy. & H. Hara*	Laurac- eae	Tree		Synonyms: Litsea umbrosa var. consimilis (Nees) Hook. f.; Tetradenia pallens D. Don. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
162.	Olax nana Wall*	Olacac- eae	Shrub	Dwarf Olax	Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
163.	Olea europaea subsp. cuspidata	Olacac- eae	Tree	Kahu, Kau	Synonyms: Olea cuspidata Wall. & G. Don, Olea ferruginea Royle Threat: Anthropological pressure (Over exploitation and Developmental activities) Uses: Heavily lopped for fodder.
164.	Olea paniculata R. Br.	Oleace- ae	Tree	Gair, Gaild	Synonym: Olea glandulifera Desf. Threat: Anthropological pressure (Development activities) Uses: Turnery, agricultural implements, fodder.
165.	<i>Oroxylum</i> indicum (L.) Kurz	Bignoni- aceae	Tree	Tarlu, Pharrai, Pharnat, Tantia	Synonyms: Bignonia indica L., Spathodea indica (L.) Pers. Threat: Anthropological pressure (Developmental activities) Uses: Bark and fruit for tanning and dyeing, seeds to decorate hats by Buddhists.
166.	Osmanthus fragrans Loureiro*	Oleace- ae	Tree	Sweet osmanthus	Synonym: Olea acuminata Wall. ex G. Don Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal, perfumery and flavouring agent.
167.	Ougeinia oojeinensis (Roxb.) Hochr.,	Fabace- ae	Tree	Sandan	Synonym: Dalbergia oojeinensis Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Agricultural implements, bast fibre for cordage.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
168.	Phanera retusa Benth.	Caesalpin- aceae	Tree	Semla	Synonyms: Bauhinia retusa Roxb., Bauhinia semla Wunderlin Threat: Anthropological pressure (Developmental activities) Uses: Edible gum 'Semla Gond'.
169.	Phanera vahlii (Wight & Arn.) Benth.	Caesalpin- aceae	Woody Climber	Maljhan, Malo	Synonym: Bauhinia vahlii Wight & Arn. Threat: Anthropological pressure (Over exploitation) Uses: Seeds as pulses, Leaves used for plates.
170.	Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	Acanthac- eae	Shrub		Synonym: Justicia thyrsiformis Hardw. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
171.	Phoenix acaulis Buch*	Arecac- eae	Shrub	Dwarf date palm	Synonyms: Phoenix acaulis var. melanocarpa Griff. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Leaves for coarse mats and brooms.
172.	Phoenix loureiroi Kunth,	Arecac- eae	Shrub	Khajur	Synonyms: Phoenix humilis Royle ex Becc. Phoenix humilis var. loureiroi (Kunth) Becc. Threat: Anthropological pressure (Developmental activities) Uses: Leaves for making mats and brooms.
173.	Phyllanthus emblica Linn.	Euphorb- iaceae	Tree	Aonla, Amla	Synonym: Emblica officinalis Gaertn Threat: Anthropological pressure (Developmental activities) Uses: Medicinal, fruit rich source of vitamin C.
174.	Picea smithiana (Wall.) Boiss.	Pinac- eae	Tree	Himalayan Spruce, Roi, Rai	Synonym: Pinus smithiana Wall. Threat: Anthropological pressure (Developmental activities) Uses: Timber.
175.	Picrasma quassioides (D. Don) Benn.	Simarubi- aceae	Shrub	Karui	Synonym: Simaba quassioides D. Don. Threat: Anthropological pressure (Developmental activities) Uses: Wood extracts as natural insecticide in organic farming, bark medicinal.
176.	Piliostigma malabaricum (Roxb.) Benth.	Caesalpin- aceae	Tree	Khatta Jhabjhora, Khatua	Synonym: Bauhinia malabarica Roxb, Threat: Anthropological pressure (Developmental activities) Uses: Fuelwood, acidic leaves edible.
177.	Pinus roxburghii Sarg.	Pinaceae	Tree	Chir, Sarol, Sirli, Klhain	Synonym: Pinus longifolia Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Timber, charcoal used by blacksmiths.
178.	Pinus wallichiana A.B. Jacks.	Pinaceae	Tree	Kail, Blue Pine	Synonym: Pinus excelsa D. Don Threat: Anthropological pressure (Developmental activities) Uses: Better timber than P. roxburghii, resinous wood used as torch.
179.	Pistacia chinensis Bunge, ssp. integerrima (J.L. Stewart) Reich.f	Anacard- iaceae	Tree	Kakkar, Kakroi	Synonym: Pistacia integrrima J.L. Stewart Threat: Anthropological pressure (over exploitation for medicinal) Uses: Galls (kakarsinghi) in native medicine, ornamental.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
180.	Pittosporum eriocarpum Royle*	Pittospor- aceae	Tree		Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Fuelwood.
181.	Pittosporum napaulense (DC.) Rehder & E.H. Wilson	Pittospora- ceae	Tree		Synonym: Pittosporum floribundum Royle Threat: Anthropological pressure (Developmental activities) Uses: Fuelwood.
182.	Populus ciliata Wall. ex Royle	Salicac- eae	Tree	Baion, Sharphara, Tilaunju, Kapasi, Pahari Pipal	Threat: Anthropological pressure (Developmental activities) Uses: Fodder for goats.
183.	Premna mollissima Roth	Verbenac- eae	Tree	Bakar, Bakarcha	Synonym: Premna latifolia Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Good fuel.
184.	<i>Prinsepia utilis</i> Royle	Rosaceae	Shrub	Bhekoi, Bhek, Bhekal, Bhekar	Threat: Anthropological pressure (For fodder) Uses: Medicinal.
185.	Prunus cerasoides Buch. Ham. ex D. Don	Rosaceae	Tree	Padam, Phaja	Synonys: Prunus puddum sensu Hook.f Threat: Anthropological pressure (over exploitation for fruit) Uses: Seedling rootstock for sweet cherry, branches as walking sticks.
186.	Prunus cornuta (Wall. ex Royle) Steud.	Rosaceae	Tree	Jamoi, Jamroi, Jamnoi	Synonym: Cerasus cornuta Wall. ex Royle Threat: Anthropological pressure (Developmental activities) Uses: Fodder, fruits eaten by hill people.
187.	Prunus undulata BuchHam. ex D. Don*	Rosaceae	Tree		Synonym: Laurocerasus undulata (BuchHam. ex D. Don) M. Roem. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
188.	Pterocarpus marsupium Roxb. *	Fabaceae	Tree	Indian Kino, Vijayasar, Bijasal,	Synonym: Lingoum marsupium (Roxb.) Kuntze Threat: Genetic aberration, Anthropological pressure (overexploitation of wood). Uses: Medicinal.
189.	Pterospermum acerifolium (Linn.) Willd.	Sterculia- ceae	Tree	Mayeng, Kanakchampa	Synonym: Pentapetes acerifolia L. Threat: Anthropological pressure (Developmental activities) Uses: Ornamental, Food plates, medicinal.
190.	Pueraria tuberosa (Roxb. ex Willd.) DC.	Fabaceae	Woody Climber	Sural, Saral, Sarur	Synonym: Hedysarum tuberosum Roxb. ex Willd. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
191.	Punica granatum L.	Lythrac- eae	Tree	Anar, Danoi	Synonym: Punica nana L. Threat: Anthropological pressure (Exploitation for fruit) Uses: Fruit edible, bark and fruit rind for tanning.
192.	Putranjiva roxburghii Wall.	Euphorbi- aceae	Tree	Jiaputa, Putijia	Synonym: Drypetes roxburghii (Wall.) Hurus Threat: Anthropological pressure (Developmental activities) Uses: Seeds are threaded into necklaces, in rosaries.
193.	<i>Pyrus pashia</i> Buch. Ham. ex D. Don	Rosace- ae	Tree	Mehul, Indian Wild Pear	Threat: Anthropological pressure (Developmental activities) Uses: Half rotten fruit eaten, walking sticks, tobacco pipes.



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Sr. **Botanical Name Family** Habit Local/ Common Synonyms/Threat/Uses Name 194. Quercus Tree Moru Synonym: Quercus dilatata Lindl. ex Fagaceae floribunda A. DC. Lindl. ex A. Threat: Anthropological pressure Camus (Exploitation for fruit) Uses: Timber, agriculture implements, valued fodder. 195. Quercus glauca Fagaceae Tree Phanat, Inai, Bani Threat: Exploitation for fruit Thunb. Uses: Same use as Q. floribunda. 196. Quercus lanata Fagaceae Tree Banj Synonym: Quercus lanuginosa D. Don Threat: Exploitation for fruit Sm Uses: Seed edible, Fuelwood. 197. Quercus Tree Ban, Bani Synonym: Quercus incana Roxb. Fagaceae leucotrichophora Threat: Anthropological pressure A. Camus (Developmental activities) Uses: Timber, fuelwood, acorn favoured by bears and squirrels. 198. Quercus Fagaceae Tree Kharsu Synonym: Quercus obtusifolia D. Don. semecarpifolia Threat: Anthropological pressure Sm. (Developmental activities) Uses: Timber, fodder, acorn favoured Shrub 199. Rauvolfia Sarpgandha Synonym: Ophioxylon serpentinum L. Apocynaserpentina (L.) Threat: Anthropological pressure ceae Benth. ex Kurz (Exploitation for medicine) Uses: Medicinal. 200. Rhododendron Ericaceae Tree Burans Synonym: Rhododendron windsorii Nutt. arboreum Sm. Threat: Over exploitation of flower for juice and wood for charcoal. Uses: Juice, fuelwood, quality charcoal. Rhus parviflora Anacard-Shrub Ninas, Ninawa Threat: Anthropological pressure Roxb. iaceae (Development activities) Uses: Medicinal. 202. Rivea ornata Convolvu-Woody Phanji Threat: Genetic aberration. (Roxb.) Choisy* Climber Anthropological pressure laceae (Developmental activities). Uses: Medicinal. Bed, Jalmala, Salix tetrasperma Salicac-Tree Synonym: Salix disperma D. Don Roxb. Laila, Bhainsh Threat: Anthropological pressure eae (Exploitation for fruit) Uses: Fodder, twigs to make baskets. 204. Saurauia Actinidi-Tree Bhakara, Synonyms: Saurauia napaulensis var. napaulensis DC. * aceae Goganda, montana C.F. Liang & Y.S. Wang Gogina, Gugna Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Ripe fruit eaten by locals. Schisandra Schisand-Woody Synonym: Kadsura propingua Wall. Climber Threat: Anthropological pressure propinqua raceae (Wall.) Baill. * (Habitat destruction due to tourism). Uses: Medicinal. 206. Schleichera Gausam, Gosam, Synonym: Schleichera trijuga Willd Sapinda-Tree oleosa (Lour.) Kusum Threat: Anthropological pressure ceae Merr. (Developmental activities) Uses: Fodder, lac produced on this tree considered finest. 2.07 Schrebera Oleaceae Tree Nathusia Threat: Genetic aberration, swietenioides swietenioides Anthropological pressure Roxb.* (Roxb.) Kuntze (Developmental activities). Uses: Ornamental potential. Bhilawa, Marking 208. Semecarpus Tree Threat: Anthropological pressure Anacardanacardium L. f iaceae Nut tree (Developmental activities) Uses: Medicinal.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
209.	Shorea robusta Roxb. ex C.F. Gaertn.	Dipteroc- rpaceae	Tree	Sal	Threat: Anthropological pressure (Developmental activities) Uses: Most important timber of northern India, Railway sleepers, Seed oil.
210.	<i>Skimmia</i> anquetilia N.P. Taylor & Airy Shaw	Rutaceae	Shrub	Kathur-chara, Gurlpata	Threat: Anthropological pressure (Leaves over exploited for essential oil) Uses: Small farming implements, essential oil.
211.	Sloanea tomentosa (Benth.) Rehder & Wilson*	Elaeocar- paceae	Tree		Synonym: Echinocarpus tomentosus Benth. Threat: Genetic aberration, Anthropological pressure (lopping for fodder). Uses: Not known.
212.	Smilax ovalifolia Roxb.	Liliaceae	Woody Climber	Ram-dataun	Synonym: Smilax macrophylla Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
213.	Sophora mollis (Royle) Baker*	Fabaceae	Shrub	Peeli Sakina	Synonym: Sophora mollis Graham in Wall. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Fuel, fodder.
214.	Sorbus cuspidata (Spach) Hedl.	Rosaceae	Tree		Synonym: Pyrus vestita Wall. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
215.	Spatholobus parviflorus (Roxb. ex DC.) Kuntze	Fabaceae	Woody Climber	Maula, Malha-bel	Synonym: Butea parviflorus Roxb. ex Threat: Anthropological pressure (Developmental activities) Uses: Seed oil used for cooking; medicinal.
216.	Spondias pinnata (L.f.) Kurz	Anacardi- aceae	Tree	Ambara, Hog plum tree	Synonyms: Mangifera pinnata L.f, Spondias mangifera Willd Threat: Anthropological pressure (Development activities) Uses: Fruit eaten raw, pickled or in curries.
217.	Staphylea emodi Wall.ex Brandis*	Staphyle- aceae	Tree	Chitra, Marcchob, Nagdaun	Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Walking sticks.
218.	<i>Stephania glabra</i> (Roxb.) Miers	Menispe- rmaceae	Woody Climber	Parha	Synonym: Cissampelos glabra Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Medicinal.
219.	Sterculia villosa Roxb. ex Sm.	Sterculi- aceae	Tree	Godgudala	Threat: Anthropological pressure (Developmental activities) Uses: Gum (katila) used as medicine.
220.	Stereospermum chelonoides (L.f.) DC.	Bignonia- ceae	Tree	Padal	Synonyms: Bignonia chelonoides L.f., Stereospermum tetragonum DC. Threat: Anthropological pressure (Developmental activities) Uses: Excellent fuelwood, produce good charcoal.
221.	Stranvaesia nussia Lindl.	Rosaceae	Tree		Synonym: Stranvaesia glaucescens Lindl. Threat: Anthropological pressure (Developmental activities) Uses: Potential ornamental value.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
222.	Symplocos cochinchinensis var. laurina (Retz.) Noot. *	Symploc- aceae	Tree	Bholiya	Synonym: Symplocos spicata Roxb. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Turnery articles.
223.	<i>Syzygium cumini</i> (L.) Skeels	Myrtace- ae	Tree	Jaman, Jamun	Synonym: Myrtus cumini L. Threat: Anthropological pressure (Developmental activities) Uses: Fruit edible, medicinal.
224.	Syzygium nervosum A. Cunn. ex DC.	Myrtac- eae	Tree	Piaman, Thuti	Synonym: Eugenia operculata Roxb. Threat: Anthropological pressure (Developmental activities) Uses: Fruit edible, agriculture implements.
225.	Taxus wallichiana Zucc.	Taxaceae	Tree	Thuner, Thuniara	Synonym: Taxus baccata L.subsp. wallichiana (Zucc.) Pilg. Threat: Anthropological pressure (Developmental activities) Uses: Bark substitute of tea, medicinal.
226.	Terminalia arjuna (Roxb. ex DC.) Wight & Arn.	Combre- taceae	Tree	Arjun	Synonym: Terminalia glabra (Roxb.) Wight & Arn/ Threat: Anthropological pressure (Fruit extract for medicine) Uses: Medicinal, agriculture implements, fuelwood.
227.	Terminalia bellirica (Gaertn.) Roxb.	Combret- aceae	Tree	Baheda	Synonym: Myrobalanus bellirica Gaertn. Threat: Anthropological pressure (Fruit extract for medicine) Uses: Fruit valuable, being one myrobalans of commerce.
228.	Terminalia chebula Retz.	Combret- aceae	Tree	Har, Harr, Hararh	Synonyms: Myrobalanus chebula (Retz.) Gaertn., Terminalia gangetica Roxb. Threat: Anthropological pressure (Fruit extract for medicine) Uses: Fruit black myrobalans of commerce. Twig galls and fruit for tanning and dyeing.
229.	<i>Terminalia</i> tomentosa Wight & Arn	Combret- aceae	Tree	Sain, Asaina	Synonym: Terminalia alata Roth Threat: Anthropological pressure (Developmental activities) Uses: Same as T. arjuna, 'tassar silkworm' reared in the Central province
230.	Tinospora sinensis (Lour.) Merr.	Menisper- maceae	Woody Climber	Gurch, Giloe, Gulancha	Synonym: Tinospora malabarica (Lam.) Hook.f.) Threat: Anthropological pressure (Exploitation for medicine) Uses: Medicinal.
231.	<i>Toona ciliata</i> M. Roem.	Meliac- eae	Tree	Tun	Synonyms: Cedrela toona Roxb. ex Rottler, Toona hexandra (Wall.) M. Roem. Threat: Anthropological pressure (Developmental activities) Uses: Chief furniture wood in region.
232.	Toona sinensis (A. Juss.) M. Roem.	Meliac- eae	Tree	Darlu, Darli, Darloi	Synonyms: Cedrela serrata Royle, Toona serrata (Royle) M. Roem. Threat: Anthropological pressure (Developmental activities) Uses: Fodder.
233.	Toricellia tiliifolia DC. *	Toricell- iaceae	Woody Climber	Tumadiya	Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Not known, however, medicinal use in Chinese pharmacopoeia.
234.	Trachycarpus takil Becc. *	Palmae	Tree	Thakil palm	Synonym: Chamaerops martiana Duthie Threat: Genetic aberration, Anthropological pressure (leaves extraction for roofing and Developmental activities). Uses: Ornamental fiber

Uses: Ornamental, fiber.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
235.	Trema orientalis (L.) Blume	Ulmaceae	Tree	Jiban	Synonym: Celtis orientalis L. Threat: Anthropological pressure (Developmental activities) Uses: Fiber, fodder.
236.	<i>Tsuga dumosa</i> (D.Don) Eich.	Pinaceae	Tree	Tansen	Synonym: Pinus dumosa D. Don Threat: Anthropological pressure (Developmental activities) Uses: Incense, bark for thatching.
237.	Turpinia cochinchinensis (Lour.) Merr. *	Staphyle- aceae	Tree	Indomalaya Turpinia	Synonym: <i>Turpinia nepalensis</i> Wall Threat: Anthropological pressure Uses: Not known.
238.	<i>Ulmus wallichiana</i> Planch.	Ulmaceae	Tree	Emroi, Imroi	Synonym: Ulmus wallichiana subsp. xanthoderma Melville & Heybroek Threat: Anthropological pressure (Developmental activities) Uses: Fiber, good fodder.
239.	Uncaria scandens (Sm.) Hutch*	Rubiaceae	Woody Climber		Synonyms: Nauclea pilosa Kuntze, Uncaria pilosa Roxb. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
240.	<i>Uraria picta</i> (Jacq.) Desv. ex DC.	Fabaceae	Shrub	Prishniparni	Synonym: Hedysarum pictum Jacq. Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.
241.	Vachellia nilotica (L.) P. J. H. Hurter & Mabb.subsp. indica (Benth.) Kyal. & Boatwr.	Mimoca- ceae	Tree	Babul, Kikar	Synonyms: Acacia arabica var. indica Benth. Acacia nilotica subsp. indica (Benth.) Brenan Threat: Anthropological pressure (Developmental activities) Uses: Agriculture implements, fodder, tannin.
242.	Ventilago denticulata Willd.	Rhamnac- eae	Woody Climber	Kali-Bel	Synonym: Ventilago calyculata Tul. Threat: Anthropological pressure Uses: Medicinal.
243.	Viburnum cordifolium Wall. ex DC. *	Caprifoli- aceae	Tree		Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Medicinal.
244.	Vitex negundo L.	Verbena- ceae	Shrub	Shimalu, Chhatimal, Nishinda	Synonym: Vitex incisa Lam. Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.
245.	Wallichia oblongifolia Griffith*	Arecac- eae	Shrub	Himalayan dwarf fishtail palm	Synonyms: Harina oblongifolia (Griffith) Griffith; Wallichia densiflora Martius. Threat: Genetic aberration, Anthropological pressure (Developmental activities). Uses: Ornamental, leaves used for thatching and brooms.
246.	Wendlandia heynei (Schult.) Santapau & Merchant	Rubiaceae	Tree		Synonym: Wendlandia exserta (Roxb.) DC. Threat: Anthropological pressure (Developmental activities) Uses: Agricultural implements, excellent soil binder.
247.	Wrightia arborea (Dennst.) Mabb.	Apocyna- ceae	Tree	Dudhi, Kutaj	Synonym: Wrightia tomentosa Roem. & Schult. Threat: Anthropological pressure (Developmental activities) Uses: Turnery articles.



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Sr. No.	Botanical Name	Family	Habit	Local/ Common Name	Synonyms/ Threat/ Uses
248.	Zanthoxylum armatum DC.	Rutaceae	Shrub	Timbur, Timru, Tejbal	Synonym: Zanthoxylum alatum Roxb. Threat: Anthropological pressure (over exploitation for medicine) Uses: Twigs used to clean teeth and fruits in gum ailments.
249.	Ziziphus mauritiana Lam.	Rhamnac- eae	Tree	Ber, Beri, Pamdi ber	Synonym: Ziziphus jujuba (L.) Gartn. Threat: Anthropological pressure (Developmental activities) Uses: Fruit eaten, agriculture implements, fuel wood.
250.	Ziziphus xylopyrus (Retz.) Willd.	Rhamnac- eae	Shrub	Bhander, Keth Ber	Synonym: Rhamnus xylopyrus Retz. Threat: Anthropological pressure (over exploitation for medicine) Uses: Medicinal.

^{*}RET Taxa

3.6.2.1

Use of Prioritized FGR Species

Table 3.5 summarizes the pattern of varied uses of prioritized 250 FGR species. Accordingly, as many as 172 species have medicinal importance, followed by 112 species used for the purpose of fuel wood. 108 species have multipurpose utility. Fruits of 52 species are being harvested for consumption as fresh fruit (e.g., Myrica esculenta, Phyllanthus emblica), dry fruit (e.g., Juglans regia), or making squashes/ juices (e.g., M. esculenta). 45 FGR species are being used as timber species or specifically in carpentry work or furniture making. Nearly, 33 per cent species (82 in number) are being exploited for fodder purpose (e.g., Quercus floribunda, Anogeissus latifolia, Bauhinia purpurea, Bauhinia racemosa). 32 species are being used in ornamental/ avenue plantations. Seeds of 11 species are being harvested for consumption in confectionary (e.g., Buchanania cochinchinensis), oil production (e.g., Shorea robusta, Diploknema butyracea). 8 prioritized FGR species are being used for the production of charcoal (e.g., Pinus roxburghii, Rhododendron arboreum, Hippophae salicifolia). Three species viz., Olea paniculata, Symplocos cochinchinensis, and Wrightia arborea are being exploited for making turnery articles. Acacia catechu is being used as a source of cutch.



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No. of Species Sr. No. Avenue/ Ornamental Tree 1. 32 2. Charcoal 8 8 3. Commonly Used for Shade in Tea Gardens 4. Fiber 22 5. Flower Buds Consumed as Vegetable 1 6. Fodder 82 7. Fruit 52 8. 112 Fuelwood 9. Medicinal 172 10. Multipurpose 108 11. Reclamation of Degraded Lands 15 12. Seeds (as food) 11 13. Source of Cutch 1 14. Timber/ Carpentry Work/ Furniture Making 45 3 15. Turnery Articles 16. Wooden Utensils by Buddhist 3

Table 3.5Summary of
Uses of
Prioritized FGR
Species

3.6.2.2

Threats to Prioritized FGR Species

Table 3.6 summarizes varied threats to prioritized FGR species in broad categories. Accordingly, 58 per cent of the prioritized FGR species (145 in number) prominently face threat on the account of varied developmental activities *viz.*, development of linear infrastructure (road and rail), widening of roads, hydropower generation, agriculture/ horticulture expansion, and ever-increasing tourism activities. Nearly one-fifth of the studied species face threat on account of genetic aberration. Twenty-seven species face threat on account of their exploitation for timber, fuelwood, and other local consumption. Two species are being threatened by forest fires. As many as thirteen species are being exploited for medicinal purposes, posing threat to their survival (Table 3.6).

Sr. No.	Threats	No. of Species
1.	Developmental Activities	145
2.	Ecotourism and Climate Change	4
3.	Exploitation for Medicine	13
4.	Forest Fire	2
5.	Genetic Aberration	51
6.	Habitat Destruction	3
7.	Lopping for Fodder	4
8.	Other Purposes	27
9.	Over Exploitation for Vegetables	1

Conservation of Forest Genetic Resources



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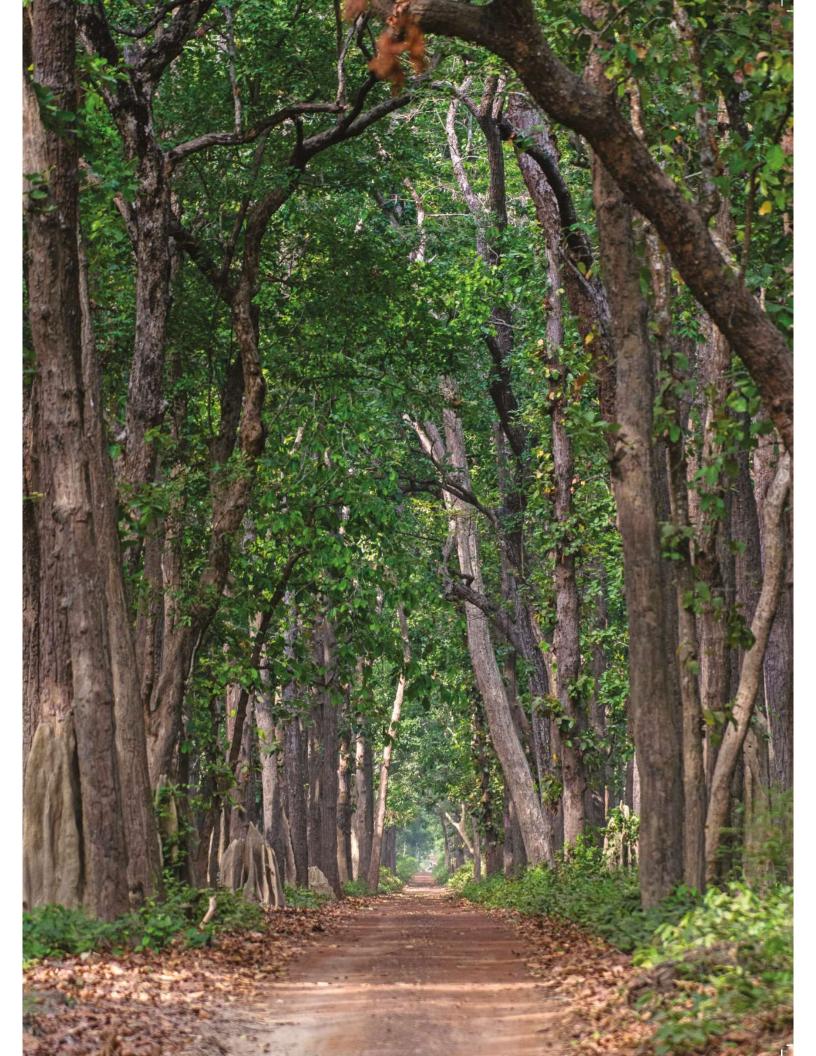
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Table 3.6Summary of
Threats Faced
by Prioritized
FGR Species

3.6.3

Population Structure and Regeneration Status

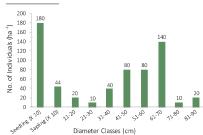
The vital information on the distribution of varied species across different districts, forest divisions and forest types; altitudinal range; population structure; and regeneration status based on exhaustive review, consultative process and extensive field work are summarized in a customized template for each of the 250 FGR species assessed in the present study (Plate 3.1 to 3.250). These species-specific profiles are presented separately for trees, shrubs, woody climbers and RET species sequentially and in an alphabetical order. Based on the profiles of 250 FGR species, summary tables on their distribution at two levels (forest types and forest divisions) and overall regeneration status were also prepared. Findings based on these tables are highlighted below:





Regeneration Status and Population Structure

12/C1c Moist Deodar Forest (n=400)



Distribution in Uttarakhand

Species occurs throughout the Central and Inner Ranges up to 2,100-3,200 m.

(Royle ex D. Don) Royle

Occurrence in Forest Types

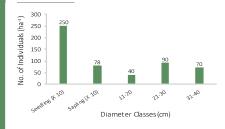
12/C1a, 12/C1b, 12/C1d, 12/C2b, 12/C2c, 14/C1a, 14/C1b and 14/1S2.

Forest Divisions

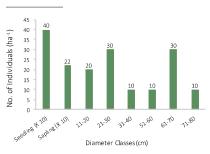
Ramnagar, Tons, Chakrata, Uttarkashi, Nainital, Pithoragarh, Upper Yamuna, Bageshwar, Mussoorie, Rudraprayag, Valley of Flowers National Park and Kedarnath Wildlife Sanctuary.

All accessed forest types exhibited 'good' regeneration as densities values were in order of seedling >saplings>adults. However, proportion of the seedlings, saplings and adult trees showed variations across studied forest types. Highest density (2,500 ha¹) of seedlings was observed in West Himalaya Upper Oak Fir Forest and lowest (400 ha¹) in Moru Oak Forest. Similar trend was also observed for saplings. Higher tree densities of lower and medium diameter classes were observed in West Himalayan Upper Oak Forest. High densities of upper diameter classes were recorded in Moist Deodar and Moru Oak Forests. It is an important timber species of sub-alpine region; hence, suitable management strategies are required for its improvement and conservation.

12/C2b West Himalayan Upper Oak Fir Forest (n=200)



12/C1b Moru Oak Forest (n=110)



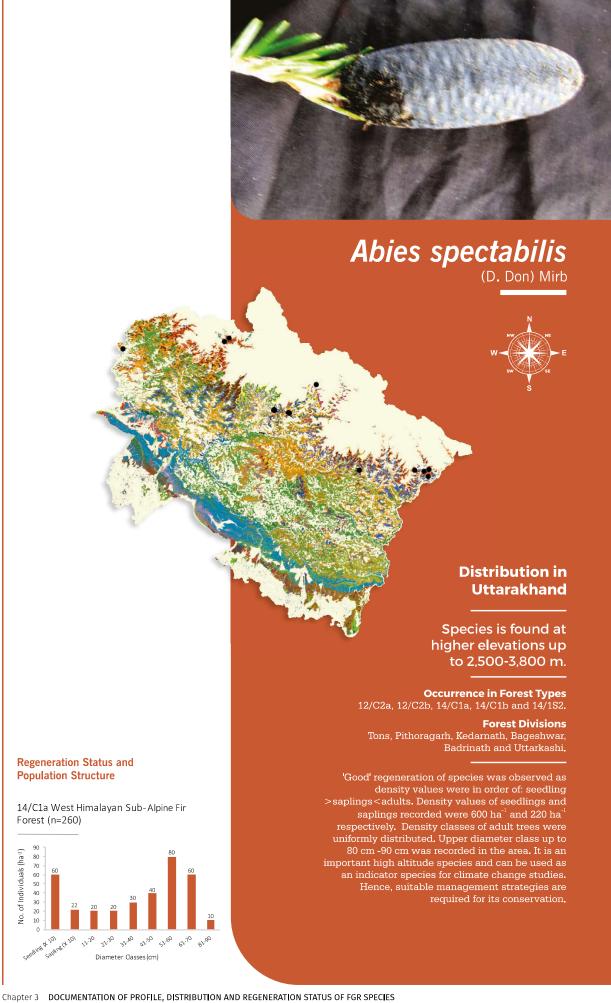
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Conservation of

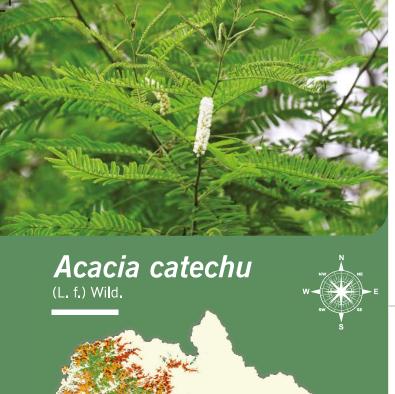


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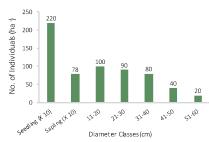
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No. of Individuals (ha-1)

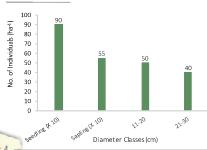


Regeneration Status and **Population Structure**

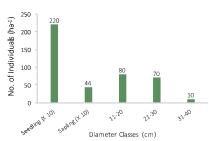
5B/C1a Dry Shiwalik Sal Forest (n=330)



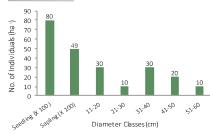
5/DS1 Dry Deciduous Scrub (n=90)



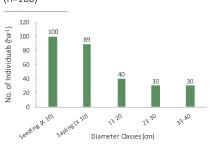
5/1S2 Khair Sissoo Forest (n=160)

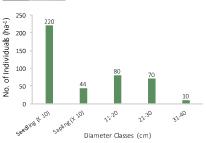


(n=100)

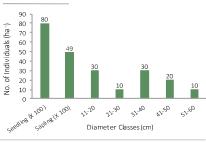


(n=100)

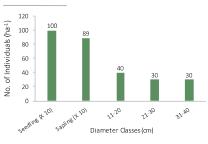




3C/C2a Moist Shiwalik Sal Forest



9/DS1 Himalayan Subtropical Scrub



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lowest 900 ha⁻¹ in Dry deciduous Scrub. Similar trend was also observed for saplings. Higher tree densities of lower and medium diameter classes (11 cm -20 cm and 21 cm-30 cm) were observed. High densities of upper diameter classes (31 cm -40 cm and 41 cm-50 cm) were also recorded in Moist Shiwalik Sal Forests. Species is very important and is exploited for 'Katha'. Suitable management strategies are required for its

3C/C2a, 3C/C3a, 5B/C1a, 5B/C1b, 5B/C2, 5/DS1, 5/1S2 and

Haridwar, Mussoorie, Dehra Dun, Narendranagar, Lansdowne,

Overall regeneration status of species in all accessed forest

and adults showed variations. Highest density (8,000 ha⁻¹) of seedlings was observed in Moist Shiwalik Sal Forest and

types was 'good' however, proportion of the seedlings, saplings

Distribution in

Species is found up to 1,300 m in riverine area.

Occurrence in Forest Types

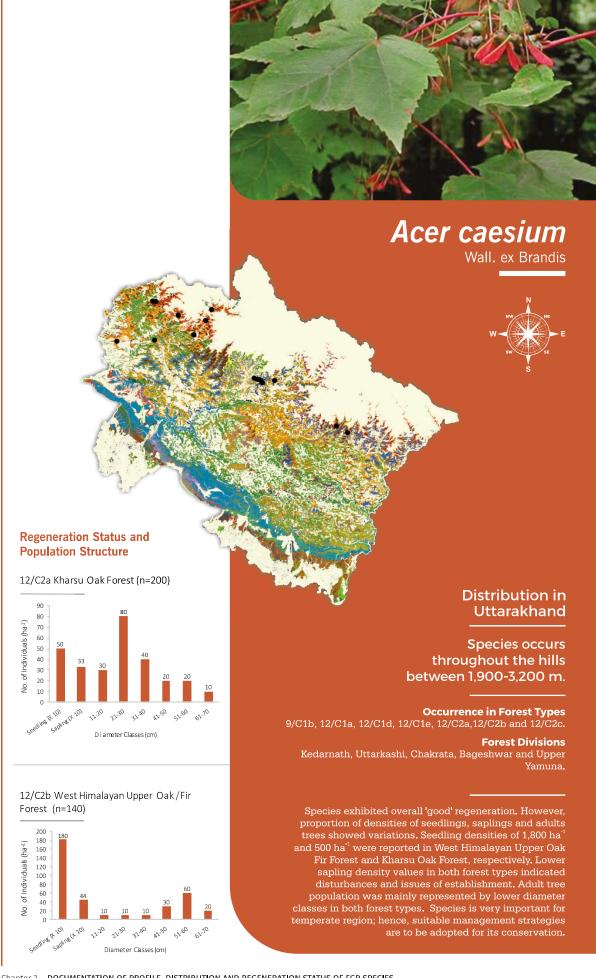
Terai Central, Terai East, Ramnagar.

improvement and conservation.

Uttarakhand

Forest Divisions

9/DS1.



Chapter 3 DOCUMENTATION OF PROFILE, DISTRIBUTION AND REGENERATION STATUS OF FGR SPECIES

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Acer oblongum

Wall. ex DC.



Distribution in Uttarakhand

Species found in Outer Himalayas and Himalayan Valleys from 450-2,100 m.

Occurrence in Forest Types 5B/C2, 9/C1b, 12/C1a, 12/C1b, 12/C1c, 12/C1d, 12/C1e and 12/2S1.

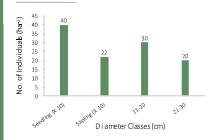
Forest Divisions

Uttarkashi, Chakrata, Tons, Mussoorie, Dehra Dun, Nainital, Tehri, Lansdowne, Pithoragarh, Champawat, Kalsi Soil Conservation Division and Binsar Wildlife

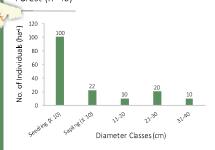
However, proportion of densities of seedlings, saplings and adult showed variations. Highest density of seedling 7,000 ha⁻¹ observed in Moru Oak Forests and lowest being 400 ha⁻¹ in Northern Dry Mixed Deciduous Forest. Adult tree population was less with just lower diameter classes. While in Ban Oak and Moru Oak forests moderately higher diameter classes were observed. Suitable strategies are required for the conservation of species.

Regeneration Status and **Population Structure**

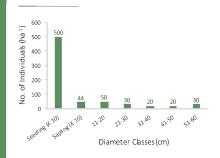
5B/C2 Northern Dry Mixed Deciduous Forest (n=50)



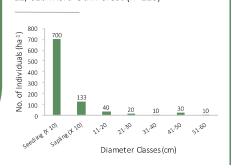
9/C1b Upper or Himalayan Chir Pine Forest (n=40)



12/C1a Ban Oak Forest (n=150)



12/C1b Moru Oak Forest (n=110)



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Acer sterculiaceum

Wall.



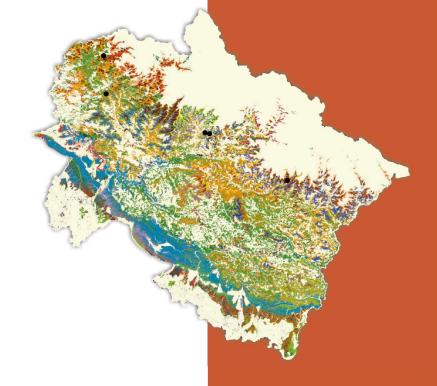
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Distribution in Uttarakhand

Species occurs throughout the hills up to 2,100 -2,700 m.

Occurrence in Forest Types 3C/C3a, 9/C1b, 12/C1a and 12/C1b.

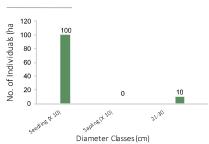
Forest Divisions

Kedarnath, Upper Yamuna and Bageshwar.

'Fair' regeneration of species was observed. Seedling density of 1,000 ha' was recorded whereas individuals sapling stage was conspicuously absent. Adult tree population was only 10 ha'. Species occurs in temperate region with scattered distribution. Species bears beautiful fruits and leaves, hence, can be exploited for its ornamental values. Population is very low in size and needs to be kept under the threatened category. Suitable conservation measures are required for its conservation.

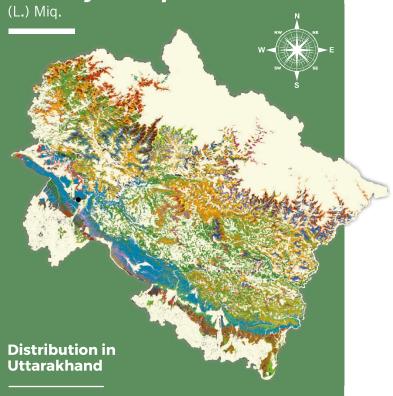
Regeneration Status and Population Structure

3C/C3a West Gangetic Moist Mixed Deciduous Forest (n=10)





Acronychia pedunculata



Species is rarely found in the Teenpani of Dehradun and Mothronwala swamp at height of about 430 m.

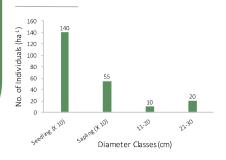
Occurrence in Forest Type 3C/C2a.

Forest Division
Dehra Dun.

Species was restricted only to Golatappar region of Dehra Dun Forest Division. Regeneration status was 'good'. Population of adult tree was just confined to only lower diameter classes up to 31 cm -40 cm. Species has very limited distribution and low population size, Hence, suitable management strategies are required for its conservation.

Regeneration Status and Population Structure

3C/C2a Moist Shiwalik Sal Forest (n=30)



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Regeneration Status and **Population Structure** 9/C1b Upper or Himalayan Chir Pine Forest (n=120) 140 of Individuals (ha-1) 120 100 80 40 Aegle marmelos Correa ex Roxb. Diameter Classes (cm) 3C/C2a Moist Shiwalik Sal Forest (n=120)450 400 350 300 200 3C/C3a West Gangetic Moist Mixed Deciduous Forest (n=20) 100 90 80 70 60 50 40 30 20 10 (ha-1) Distribution in 21.30 **Uttarakhand** Diameter Classes (cm) Species is found up to 1,000 m in the dry miscellaneous forests and less frequent in moist 5/1S2 Khair-Sissoo Forest (n=70) forests in Garhwal and Kumaon regions. Individuals (ha-1) 40 35 30 25 **Occurrence in Forest Types** 3C/C2a, 3C/C2c, 3C/C3a, 5B/C1a, 5B/C1b, 5B/C2, 5/DS1, 5/1S2, 9/C1b and 9/DS1. **Forest Divisions** Ramnagar, East Terai, Badrinath, Rudraprayag, Haridwar, Haldwani, Terai Central, Narendranagar, Lansdowne, Dehra Dun, Kalsi Soil Conservation Division, Corbett National Park, Nandhaur Wildlife Sanctuary and Rajaji Tiger Reserve. Diameter Classes (cm) 3C/C2c Moist Terai Sal Forest (n=30) proportion of seedlings, saplings and different diameter classes showed variations. Highest seedling density (4,000 ha⁻¹) was of Individuals (ha-1) recorded in Moist Shiwalik Sal Forest and lowest in Upper or 50 Himalayan Chir Pine Forest (120 ha⁻¹). Similar trend was observed in 40 case of saplings. Density of adult trees was minimum (10 ha⁻¹) in 30 density class of 21cm-30 cm in West Gangetic Moist Mixed 20 Deciduous Forest and maximum (120 ha⁻¹) in Moist Shiwalik Sal Forest. Higher adult tree densities were observed in lower and 10 Š middle diameter classes, suggesting species is evolving. Gene pool

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Chapter 3 DOCUMENTATION OF PROFILE, DISTRIBUTION AND REGENERATION STATUS OF FGR SPECIES

Diameter Classes (cm)

is very narrow, therefore, wild populations are required to be

conserved for future improvement programmes.

WE 4 70)



Aesculus indica





Distribution in Uttarakhand

Species found in the shady ravines between 1,500 - 2,900 m in Kumaun and Garhwal regions.

Occurrence in Forest Types 9/C1b, 12/C1a, 12/C1b, 12/C1c, 12/C1d, 12/C1e, 12/C2a, 12/C2b,

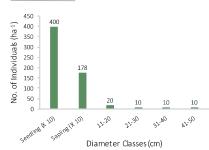
Forest Divisions

Champawat, Uttarkashi, Bageshwar, Nainital, Mussoorie, Nanda Devi, Pithoragarh, Rudraprayag, Kedarnath Wildlife Division and Govind Pashu Vihar.

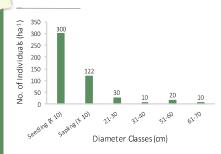
Overall regeneration of species was 'good'. Highest seedling and sapling densities of 4,000 ha⁻¹ and 1,780 ha⁻¹ were observed in Ban Oak Forest. Despite higher densities of seedlings and saplings, they were not converted into adult trees in showing low density of adult trees. On the other hand, in spite of low densities of seedlings and saplings in West Himalayan Upper Oak/Fir Forest, densities of adult trees in different diameter classes were comparatively higher. Species is a beautiful tree and can be promoted for ornamental purpose. Hence, suitable strategies are required for its conservation and improvement programmes.

Regeneration Status and **Population Structure**

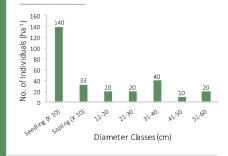
12/C1a Ban Oak Forest (n=50)



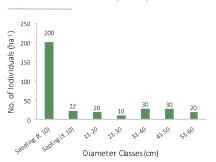
9/C1b Upper or Himalayan Chir Pine Forest (n=70)



12/C2b West Himalayan Upper Oak/Fir Forest (n=110)



12/C1b Moru Oak Forest (n=110)



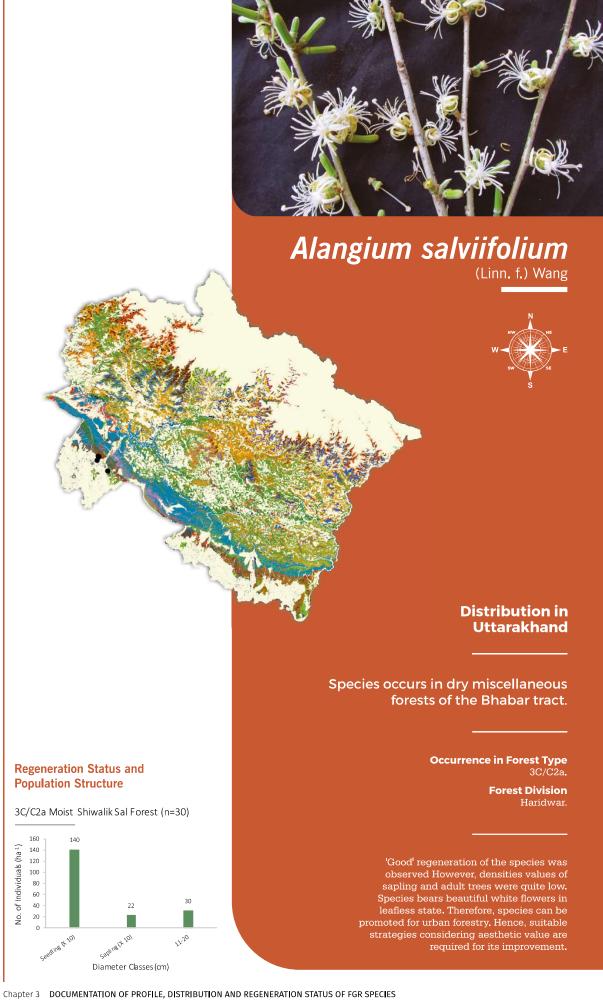
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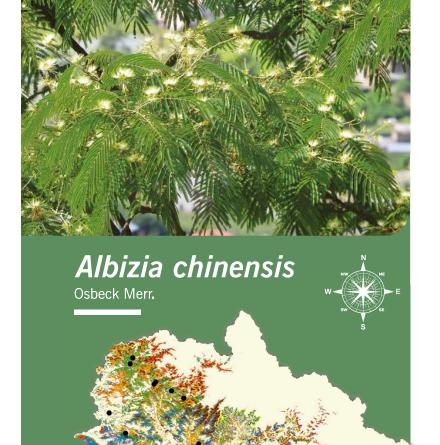


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Distribution in Uttarakhand

Species occurs throughout the area up to 1,500 m. Scarce within the hills, but fairly common along the outermost range and in the Bhabhar.

Occurrence in Forest Types 3C/C2a, 5B/C2, 9/C1a, 9/C1b and 12/C1a.

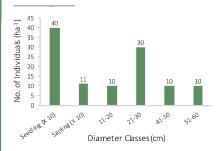
Forest Divisions

Chakrata, Dehra Dun, Uttarkashi, Bageshwar, Rudraprayag, Tehri Dam-I, Mussoorie and Tons.

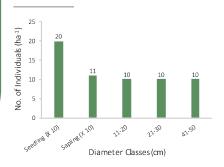
The species regeneration exhibited 'good'. Seedling density was observed at 400 ha⁻¹ in Lower or Shiwalik Chir Pine Forest while it was 200 ha⁻¹ in Ban Oak Forest. Adult tree population was quite low indicating poor establishment of seedlings into saplings. Densities of adult trees were low in all diameter classes, indicating low gene pool. Therefore, suitable management strategies are to be developed for its conservation and improvement.

Regeneration Status and Population Structure

9/C1a Lower Shiwalik Chir Pine Forest (n=60)



12/C1a Ban Oak Forest (n=30)



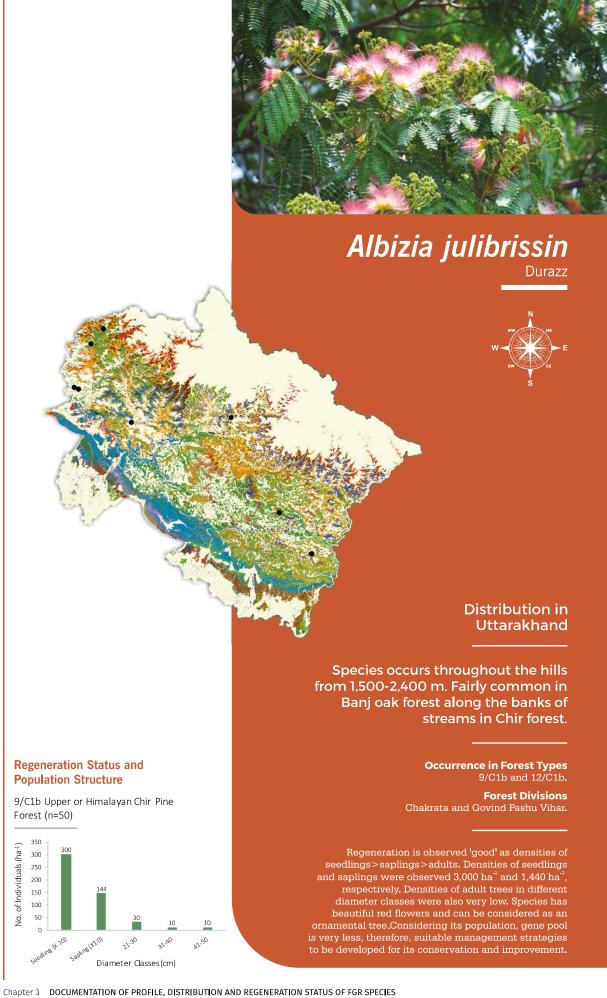
Conservation of Forest Genetic Resources



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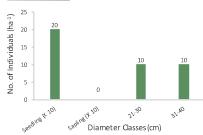
Establishment Excellence on (CoE-FGR)

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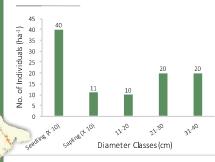


Regeneration Status and **Population Structure**

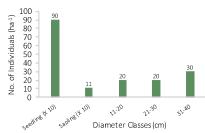
5B/C2 Northern Dry Mixed Deciduous Forest (n=20)



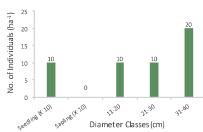
3C/C2a Moist Shiwalik Sal Forest (n=50)



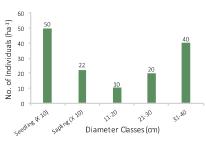
3C/C3a West Gangetic Moist Mixed Deciduous Forest (n=70)



9/C1b Upper or Himalayan Chir Pine



12/C1a Ban Oak Forest (n=70)



Albizia lebbeck

Distribution in Uttarakhand

Forest Divisions

Species is found in 300 to 1,600 m in the

Rudraprayag, Haridwar, Tehri Dam –I, Terai Central, Tehri, Govind Pashu Vihar, Nand Prayag, Alaknanda Soil Conservation, Champawat, Nandhaur Wildlife Sanctuary, Ramnagar, Uttarkashi,

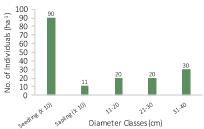
Species depicted 'good' regeneration in all forest. Highest seedling

forests in Garhwal and Kumaon region.

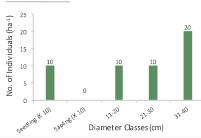
Rajaji Tiger Reserve and Kedarnath Wildlife Sanctuary.

Occurrence in Forest Types 3C/C2a, 3C/C3a, 5B/C2, 5/1S2, 9/C1b and 12/C1a.





Forest (n=40)





Conservation of Forest Genetic

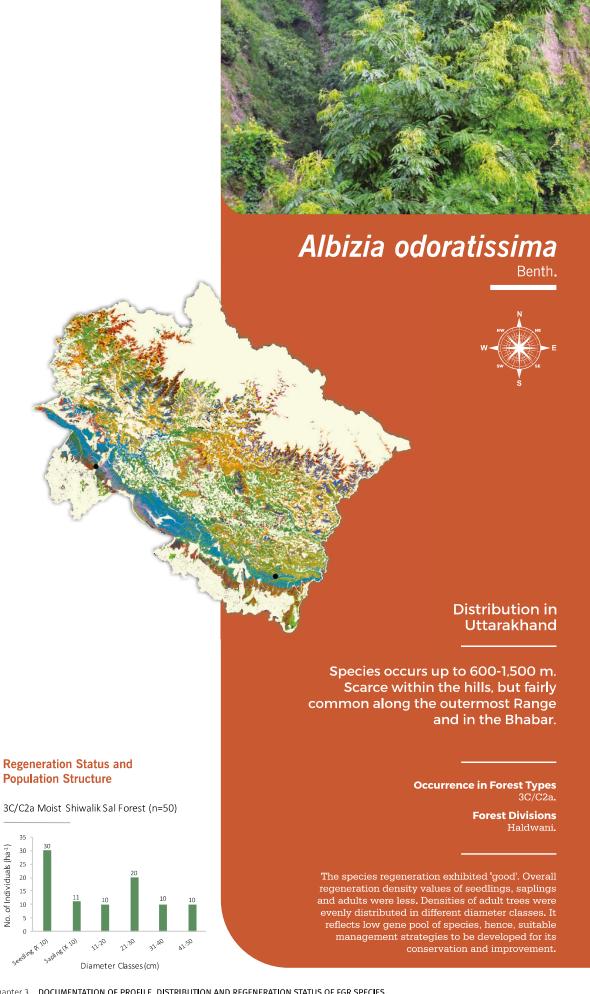


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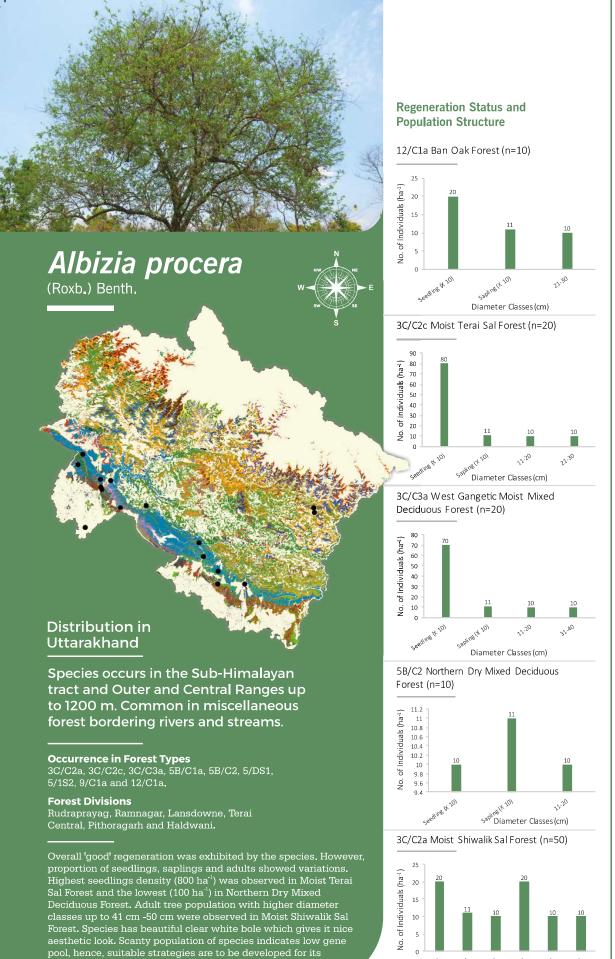
PART 2 Documentation of FGR



Chapter 3 DOCUMENTATION OF PROFILE, DISTRIBUTION AND REGENERATION STATUS OF FGR SPECIES

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conservation and improvement.

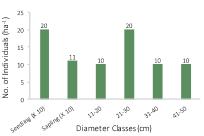
Conservation of Forest Genetic

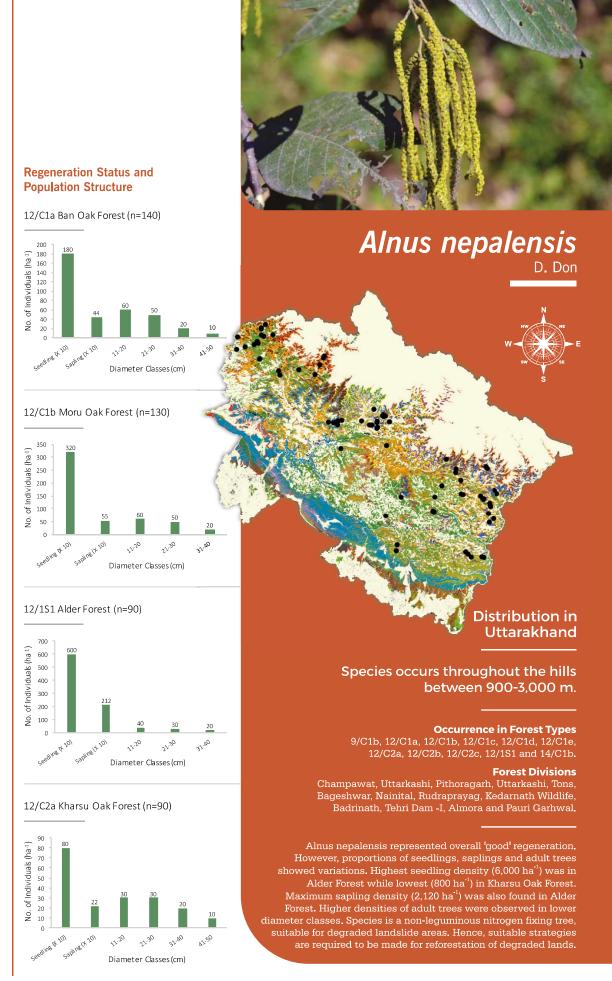


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Forest Genetic Resources

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Chapter 3 DOCUMENTATION OF PROFILE, DISTRIBUTION AND REGENERATION STATUS OF FGR SPECIES





Distribution in Uttarakhand

Species is found in Jaunsar and Tehri-Garhwal, usually at low elevations, generally fringing the banks of rivers and streams.

Occurrence in Forest Types 12/C1c and 12/C1d.

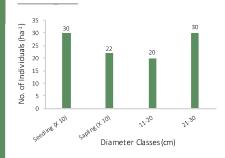
Forest Divisions

Tons, Kedarnath and Govind Pashu Vihar.

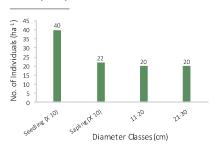
The species depicted overall 'good' regeneration. Seedling densities of 400 ha⁻¹ and 300 ha⁻¹ were observed in Western Mixed Coniferous Forest and Moist Deodar Forest, respectively. Sapling density (220 ha⁻¹) was same in both forest types. Similar trend was observed for adult tress. Species is a non-leguminous nitrogen fixing tree, suitable for restoration of degraded landslide areas. Hence, suitable strategiesare to be made for reforestation of degraded lands using this species.

Regeneration Status and Population Structure

12/C1c Moist Deodar Forest (n=50)



12/C1d Western Mixed Coniferous Forest (n=40)



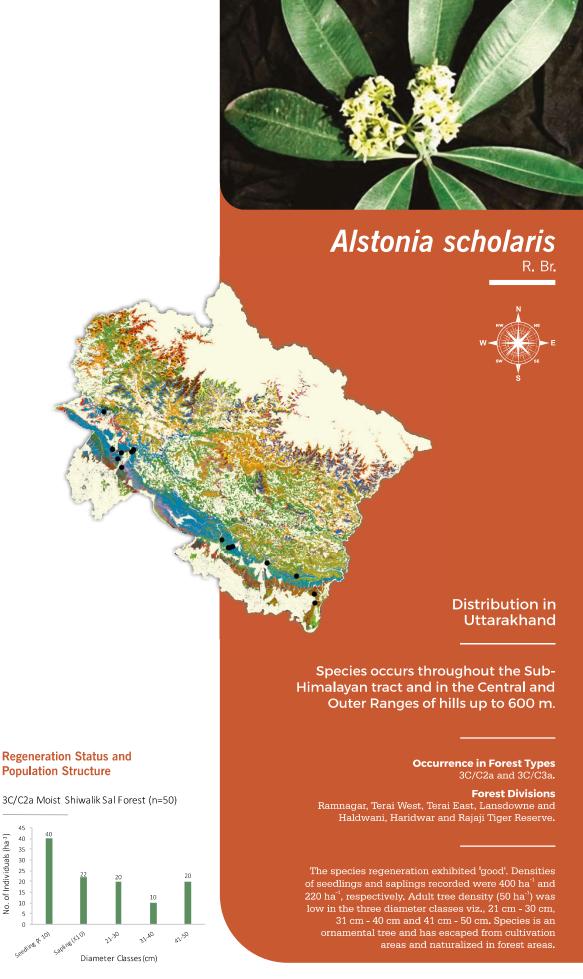
Conservation of Forest Genetic Resources



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Establishment Excellence on Forest Genetic Resources (CoE-FGR)

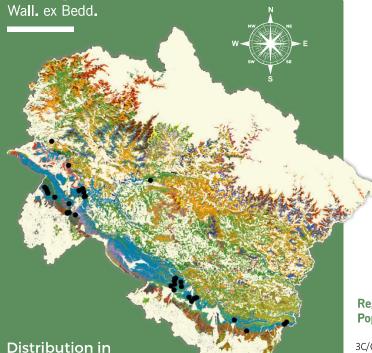
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Uttarakhand State

of Individuals (ha-1)



Anogeissus latifolia



Species is found up to 150 to 950 m in the dry and moist miscellaneous forests in Garhwal and Kumaon regions.

Occurrence in Forest Types 3C/C2a, 3C/C3a, 5B/C1a, 5B/C1b, 5B/C2, 5/1S2 and

Forest Divisions

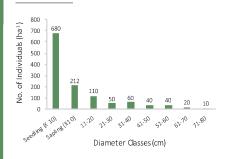
Uttarakhand

Ramnagar, Champawat, Dehra Dun, Narendranagar, Lansdowne, Rudraprayag, Haldwani and Rajaji Tiger

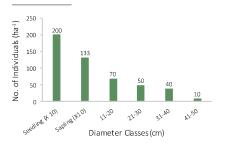
The species Regeneration depicted 'good'. Seedling densities estimated were 6,800 ha' and 2,000 ha' in Moist Shiwalik Sal Forest and Northern Dry Mixed Deciduous Forest, respectively. Saplings and adult trees of different diameter classes were higher in Moist Shiwalik Sal Forest than Northern Dry Mixed Deciduous Forest. Species is an important fodder tree species. 'Van Gujars' heavily lop leaves for their cattle, Hence, suitable management strategies are required to be developed for its conservation and sustainable lopping.

Regeneration Status and **Population Structure**

3C/C2a Moist Shiwalik Sal Forest



5B/C2 Northern Dry Mixed Deciduous Forest (n=170)



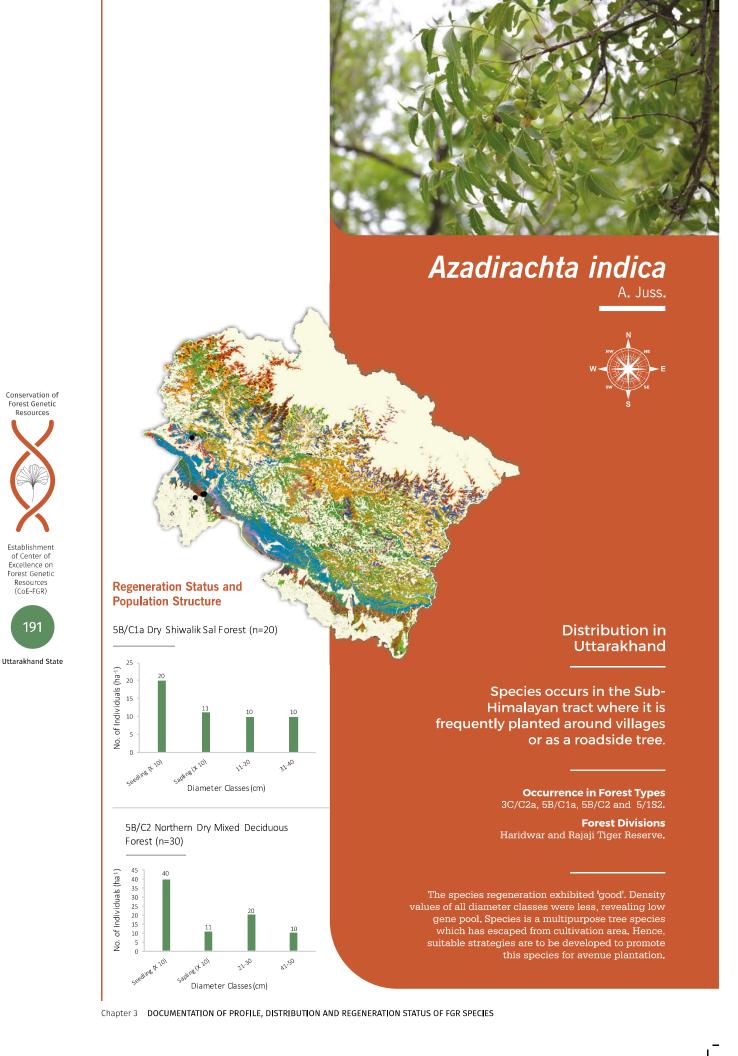
Conservation of



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Forest Genetic Resources

Establishment Excellence on Forest Genetic Resources (CoE-FGR)



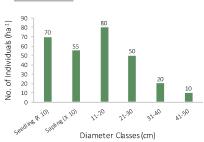
Conservation of Forest Genetic

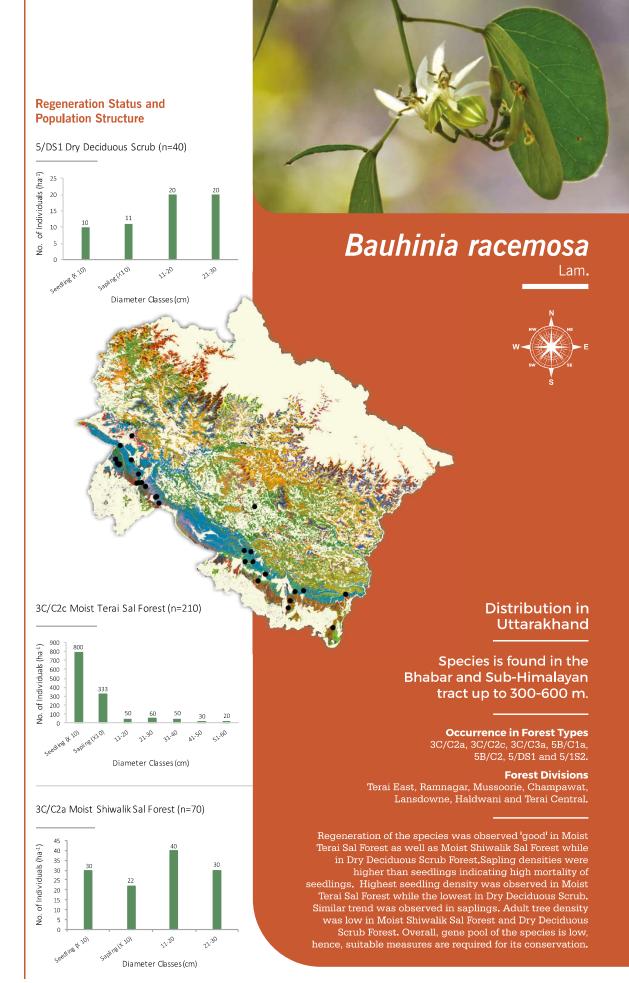


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Establishment of Center of Excellence on Forest Genetic Resources (CoE-FGR)

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Chapter 3 DOCUMENTATION OF PROFILE, DISTRIBUTION AND REGENERATION STATUS OF FGR SPECIES



Bauhinia variegata

Species occurs throughout the hills between 300-1,800 m. Common in both miscellaneous and Chir forests, especially on southern aspects and

limestone soils.

Distribution in

Uttarakhand

Occurrence in Forest Types 5B/C2, 9/C1b, 9/DS1, 12/C1a, and 12/C1c.

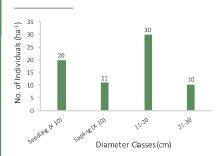
Forest Divisions

Rudraprayag, Tehri Dam -I, Chakrata, Kedarnath Wildlife and Lansdowne.

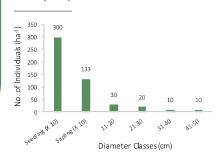
forest types. Seedling and sapling densities of 3,000 ha⁻¹ and 1,330 ha⁻¹ were obtained for Northern Dry Mixed Deciduous Forest. However, in Ban Oak Forest values were: 200 ha⁻¹ and 110 ha⁻¹, respectively. In both the forest types, low adult tree population was observed. Wild gene pool of species is less, hence, suitable strategies are to be developed for its conservation and improvement.

Regeneration Status and **Population Structure**

12/C1a Ban Oak Forest (n=40)



5B/C2 Northern Dry Mixed Deciduous Forest (n=70)



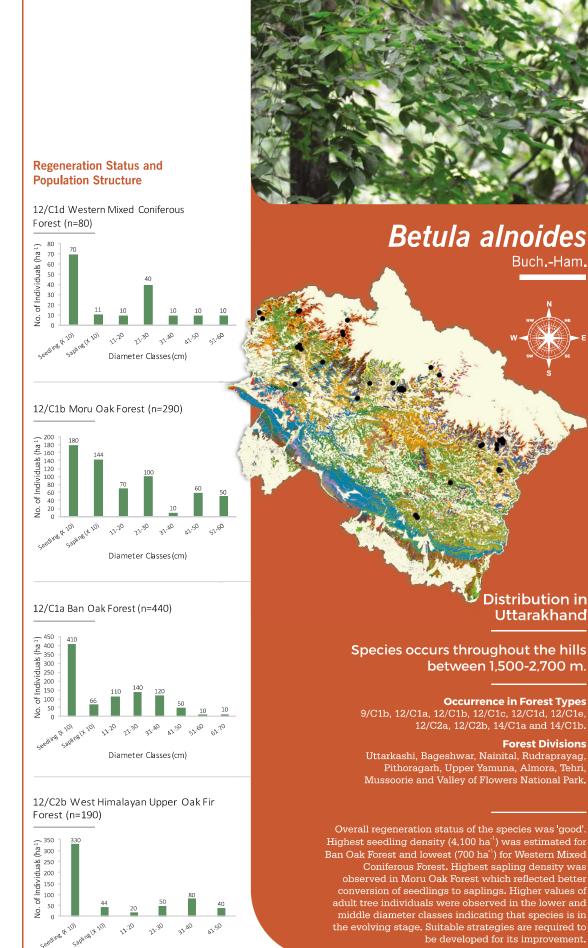
Conservation of



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Establishment

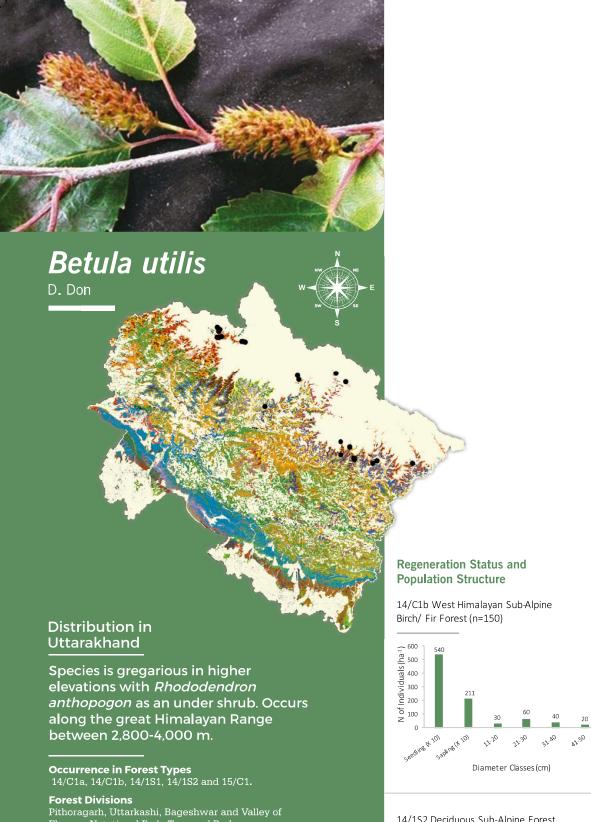
Excellence on Forest Genetic Resources

(CoE-FGR)

Uttarakhand State

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Diameter Classes (cm)



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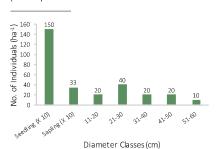
National Program for Conservation and

Development of Forest Genetic

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14/1S2 Deciduous Sub-Alpine Forest (n=110)



Overall regeneration status of the species was 'good'. The proportion of densities of all stages showed variations. In West Himalayan Sub-Alpine Birch Forest, densities of seedlings and saplings estimated were: 5,400 ha⁻¹ and 2,110 ha⁻¹, respectively. However, in Deciduous Sub-Alpine Forest values were 1,500 ha⁻¹ and 330 ha⁻¹, respectively. Adult tree density was also observed higher in West Himalayan Sub-alpine Birch Forest. It is a 'timber line species' which is used as an indicator species for climate change studies. Hence, suitable measures are to be adopted for its conservation.

Flowers Notational Park, Tons and Rudraprayag.