FRI

Project 1: Collection and dissemination of market information on commercially important plants of Uttarakhand

Findings: The original project period expired on 31-03-08. However, the funding agency i.e. National Medicinal Plants Board of Govt. of India granted extension upto 31st March 2009. The field project activities are, thus completed.

Project 2: Preparation of working Plan of Dadra and Nagar Haveli Forest Division

Findings: Draft Final Report submitted to Dadra and Nagar Haveli Forest Department for acceptance.

Project 3: Delhi Development Report, Forest, Tree Crop Management, Greening of Delhi

Findings: Chapter on Forest, Tree Crop Management, and Greening of Delhi had been written and re-submitted to the funding agency after incorporating the necessary enhancement requested by funding agency.

Project 4: Demand & Supply of medicinal plant sand produce grown / found in Haryana

Findings: District wise data pertaining to cultivation, collection and demand and supply position of 11 selected medicinal plants in the state of Haryana revealed that currently there are 56 functional herbal units in the state and 66 active traders dealing in medicinal plants trade. The study estimated a demand of 690 MT/annum of these species by various herbal units, of which 379 MT is being met from within state by the local traders. Over 500 acres of land area is under cultivation of various medicinal plants.

Project 5: Researches on natural decay resistance of juvenile timbers like poplars [DST sponsored FRI 283/Path-18/External]

Findings: The information regarding the natural decay resistance of poplar clones has for the first time been brought out in India. It is a misconception that poplar wood is not durable. However, the present study reveals otherwise. There is definite variation among the clones/source material for decay resistance; even within same clone of different locations. Poplar blocks are more susceptible to the attack of the white rot test fungus *Pycnoporus sanguineus* than the brown rot test fungus *Gloeophyllum striatum*. Brown rot fungi are more confined to higher altitude regions and from the findings of the present study, it can be suggested that poplar (*Populus deltoides*) wood can be safely used for construction and furniture making at high altitudes.

Unlike most traditional timber species, heartwood of poplar is more susceptible to decay fungi than sapwood. This quality can be used while peelings are made for plywood manufacture. Leaving a central core of inner-wood would give a decay resistant material.

Decay resistance varies within a tree from base to top, maximum resistance observed at 2.5 m height, above and below it decreased considerably. Resistance was more at the base than at the top of the tree. This quality can be used for selecting logs one meter above and below 2.5 meter from the base for selecting material for manufacturing decay resistant plywood and panels.

Clone G-48 from Pind Khakli, Hoshiyarpur and S7C15 from WIMCO, Rudrapur are highly resistant clones against decay. These materials can be used selecting logs one meter above and below 2.5 meter from the base for making decay resistant plywood as well as for construction and furniture making.

Project 6: Income generation for women in rural areas of Uttarakhand through vermicomposting of organic solid waste into manure.

Findings: Four pit vermicomposting unit/ demonstration unit was constructed in FRI campus. On campus and off campus trainings were organized for the women folk of Shivpuri, Kotada, Aamwala, Kandoli, Phoolsani, Bhagwanpur, Rajawala and Telpura villages. Two vermimelas were organized. Total 775 women folk were given on campus and off-campus training and 23 vermicomposting units were constructed on the lands of the beneficiaries of phoolsaini village. Earthworms were cultured in FRI and vermicompost distributed to the rural women.

Project 7: Impact of tourism on Environment of Roopland and Pindari of Nanda Devi Biosphere Reserve of Uttrakhand

Findings: Tourist trend of both the areas, vegetation survey / analysis along the trek routes, soil samples collection and analysis for their physico-chemical characteristics along the trek route and control sites, collection of information for socio-economic studies of both the areas like village wise human population, caste composition, literacy rate, livestock population, people's participation in tourism etc have been done. For participation of stakeholders in tourism, environmental awareness among the local people, meetings were held at Khati, Vachham, Wan, LohaJung, Mundoli etc. villages of both the study sites.

Project 8: Studies on population status and berberine content in different provenances of *Berberis aristata* DC in H.P. and standardization of its propagation techniques (funded by DBT)

Findings : Chemical method for estimation of berberine in the roots of *Berberis aristata* was standardized. Forty three samples of roots of different provenances of Himachal Pradesh received from HFRI, Shimla were analyzed for berberine using the standardized method. Maximum berberine concentration was found to be in Kharapathar (1.25%), Kinnaur and Shimla (2.50% each) provenances.

Project 9: Deployment of the promising F1 hybrids of *Eucalyptus citriodora* and *Eucalyptus torelliana* for establishment of vegetative multiplication garden and their field trials [FRI/338/G & TP-17/External/2006-2009]

Findings: Natural (spontaneous) hybrids of *E. torelliana* and *E. citriodora* have been picked up based on established morphological genetic makers. To evaluate the growth performance, the hybrids along with the parents and proper control have been established in field trials at 10 locations in the state of Punjab, Haryana, Uttarakhand and Uttar Pradesh. Some of the hybrids between *E.citriodora* and *E.torelliana* displayed superior growth at the age of one and half year. Hybridization has released a new spectrum of variation for making useful selections from these two species. The resistance of hybrids to *Cylindrocladium quinqueseptatum* inherited from *E. torelliana* parent may be helpful for planting the hybrids on sites where *E.citriodora* is prone to the fungus. Some of the genotypes of F_2 generation of FRI- 4, *E. citriodora* and *E. torelliana* parents also showed good growth. Preliminary studies carried out on oil contents of F_1 hybrids of *E. citriodora* and *E. torelliana* have revealed variation in yield and odour. The vegetative multiplication garden of selected genotypes has been established at FRI to get rejuvenated shoots for conducting experiments on rooting of cuttings.

Project 10: DNA fingerprinting of shisham (*Dalbergia sissoo*) clones planted in Punjab [FRI-364/G&TP-21/External]

Findings: Sixty seven clones of shisham (*Dalbergia sissoo*) obtained from Punjab Forest Department were characterized and fingerprinted using RAPD-DNA markers. Twenty two most divergent and distant clones were identified and recommended to Punjab Forest Department for using those clones in their plantation and improvement programs. The level of genetic diversity existing between clones has been estimated and the closely related clones were listed. DNA fingerprints of 67 clones developed and provided to Punjab Forest Department.

Project 11: Development of Live Red Data Book [FRI-277/Bot-42/External/2006-2009]

Findings: Rare and threatened species (*Buchanania lanceolata, G. travancorica, Calophyllum calaba , G. wightii ,Coscinium fenestratum, Humboltia vahliana Cyathea nilgirensis, Myristica malabarica Cyrtostachys renda , Poeciloneuron indica ,Diospyros buxifolia,Syzygium mundagam ,Garcinia , Diospyros buxifolia, Myristica malabarica- , Calophyllum calaba, Garcinia wightii , Garcinia travancorica, Humboltia vahliana , Buchanania lanceolata)* collected from different parts of India and species were reintroduced in the Botanical Garden.

Project 12: Expert system for Indian woods - their microstructure, identification, properties and uses

Findings: Final Draft report' and "Users Manual" submitted. Suggestions received on the same are being incorporated.

Project 13: Wood Anatomy of important commercial timbers of Assam with notes on their properties and uses.

Findings: Described wood anatomy, properties and end uses of 52 timber species from Assam state. The important findings of the project are given below:

1. The card and dichotomous key will ensure the correct identity of the woods of selected tree species of Assam state for utilization point of view and for further researches. It was prepared on the basis of 178 wood anatomical and physical features.

2. Cluster analysis was also done to see the affinity of different species on the basis of the 178 wood anatomical and physical features plus 4 characters of form and commercial importance. Dendrogram showed that species belonged to same genera and genera to same family grouped together while genera of different families grouped separately. For example, members of Magnoliaceae and Dilliniaceae grouped together. In the same way species belongs to Elaeocarpaceae grouped in the same cluster. It showed that physical and wood anatomical features had also significance in taxonomy and phylogeny.

3. Dichotomous key was prepared for the genus *Elaeocarpus* and *Dillenia* at species level.

Project 14: Development of micropropagation protocol for clonal multiplication and germplasm conservation of *Swertia chirata* Buch.-Ham. A medicinally important herb[FRI-333/Bot.-47-Ext. (NMPB, New Delhi)]

Findings : In vitro shoots of Swertia chirata were multiplied on large scale. 10-15 fold multiplication was obtained on MS medium supplemented with 1.0mg/l BAP + 0.5mg/l IAA + 50mg/l Ads. In vitro rooting was standardized. 92% rooting was obtained on ½ strength MS medium supplemented with 1.0mg/l IBA.

Rooted plantlets were hardened and acclimatized under control conditions, thereafter, transferred to soil and pots. A complete tissue culture protocol has been developed.

Project 15. Study on the impact of riverbed material collection on Silviculture, ecology and environment in Uttarakhand Himalayas. (Funded by UFDC).

Findings: Field studies were initiated in 7 rivers viz. Yamuna and Amlawa of Chakrata Forest Division, Gaula, Dabka, Nandaur and Nihal of Haldwani Forest Division and Kosi of Ramnagar Forest Division of Uttarakhand. Data were collected with respect to the impact of material extraction on ecological successions, accumulation of debris, change of river course, soils, volumes of ditches and gradient of catchments as well as lower courses. The following recommendations were made as per findings of study:

- Treatment of upper catchments to reduce debris transported downstream.

- The extraction of riverbed materials in the centre portion of the river is essential to control bank erosion during the influence of flood in rainy season. It is necessary to follow strict rules of extraction by leaving at least 25 m control wide strips on both the sides of the river. The soil on both the sides of the strips should be replenished and controlled by making spurs and dykes at suitable interval (50 m). It will not only bind the soil but also make favourable condition for regeneration and aggregation of species. The spurs will prevent debris accumulation in the adjoining forests.

- The monitoring of extraction area is necessary to prevent formation of deep ditches and removal of soil. Quantity of debris /annum should be calculated from extraction sites by random selection of ditches per hectare. Monitoring involves measurement of chemical, physical, and biological parameters to evaluate the magnitude of change that occurs following remedial and restoration activities and to estimate the rate of recovery of an ecosystem. The patch should be regulated where heavy extraction is done. This work is required to be done in Gaula and Yamuna rivers where extraction is not being regulated. This may cause damage to the ecology of the river and loss of property and life.

- The extraction of materials should not be started from the river mouth in case of perennial rivers. It may cut the river to other direction as in the case of Asan and Timli areas where river course has been changed and back flow is noticed at some places. It creates loss of water in the river and also loss to aquatic fauna.

Plate 1.1 Debris accumulation in untrained rivers-damage to forest vegetation

- The extraction helps in deepening of central river channel, the water in rainy season flows in this channel without making bank erosion. The deepening of central channel enhances succession of the bank resulting regeneration of desired species. Nihal river is an example where debris have been accumulated in the centre of the river as a result the flood water enters in the nearby agricultural fields and also causes loss of property and lives. Regeneration and succession is badly affected due to heavy debris accumulation. The accumulation of debris is not only harm to forest regeneration.

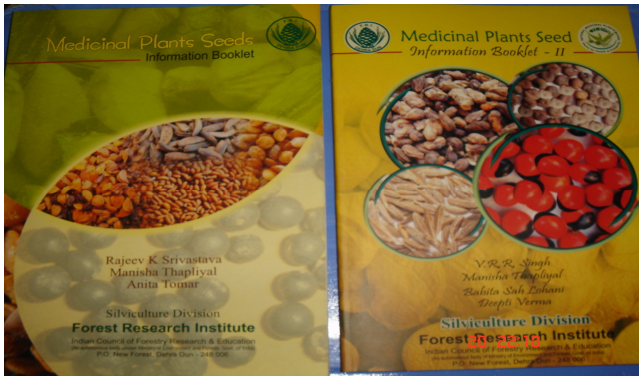
- The extraction of riverbed materials should be incorporated in the Working Plans of respective divisions as the river mining work is carried out in forest areas of the divisions.

Project 16: Development of Silvicultural practices for promoting cultivation of *Taxus baccata*, *Rhododendron arboreum* and *Phyllanthus amarus* (GO/ UA-18/ 2005) (funded by NMPB.)

Findings: It was observed that germination of freshly harvested seeds in *Phyllanthus amarus* was slower than that of older seeds. Seeds from the first capsules to dehisce after harvest (dark green seeds) had higher percentage germination than those from capsules dehiscing later (light tan seeds). Experiment was carried out on the Effect of Nitrogen and Phosphorus doses on the Biomass production of *Phyllanthus amarus* plants in nursery stages. The results showed that N30P50 had highest the plant height, number of branches, collar diameter, root length, fresh and dry weight of shoot. Further increase in level caused general decrease in plant growth rate. *Phyllanthus amarus* seeds were broadcasted for germination at three different degraded sites in Uttarakhand (Raipur, FRI and Premnagar). It was observed that 5 cm X 5 cm spacing gave highest biomass percentage in *P. amarus.* Experiment was conducted on rooting of branch cuttings of *Taxus baccata* and *Rhododendron arboretum* at Chakrata nursery. It was concluded that best results were recorded in 10,000 ppm IBA in both species (Ta*xus baccata* and *R. arboreum).* Morphological observation of flower study of *Taxus baccata* was conducted. Grafting and air layering in Rhododendron were also performed.

Project 17: Development of Technological package for the production and quality evaluation of seeds of important medicinal plant species under National Medicinal Plant Board (Project No. GO/UA-8/2005).

Findings: Seeds of 100 species of medicinal plants were collected from Ranikhet (Almora), Rishikesh, Mandal (Gopeshwar), Munsiyari (Pithoragarh) and Ramnagar in Uttarakhand. Seeds were extracted, cleaned and upgraded with the help of dodder sieve and gravity separator. The viability of seeds was evaluated by direct germination test and indirectly through TTZ test. Seed morphological parameters such as seed length, width, shape, colour, 1000 seed weight, number of seeds in a single fruit and number of seeds in 1 kg were recorded. Seeds were pretreated with different growth promoters such as GA_3 0.1%, KNO_3 0.2%, H_2O_2 0.1% and subjected to germination test monthly.



Two information booklets on Medicinal Plants Seeds

Some of the important medicinal species on which studies were conducted are *Abroma augusta, Arus precatorius, Aegle marmelos, Andrographis paniculta, Artemisia vulgaris, Asparagus racemosus, Berberis asiatica, Bergenia ligulata, Catharanthus roseus, Celastrus paniculatus, Coleus barbatus, Costus speciosus, Cymbopogon martini, Gloriosa superba, Hippophae salicifolia, Lepidium sativum, Myrica nagi, Ocimum gratissimum, Peganum harmala, Plantago ovata, Potentilla fulgens, Saussurea lappa, Solanum nigrum, Woodfordia frutocosa,* etc. The research findings has been compiled in the form of two booklets on medicinal plants seeds.

Project 18: Raising of Demonstration Plantations for Augmenting Fuelwood and Fodder Resources and Promoting Income Generation in Two Villages of Uttarakhand[Funded by: Uttarakhand Council of Science and Technology]

Status: Under this project, model plantations of fuel, fodder and income generating species were established in two villages in Uttarakhand. Socio-economic survey showed greater requirement of fuel and fodder species in village Jadi, Chakrata whereas income generating species were in greater demand in village Hadam Dandasli, Dist. Tehri Garhwal. Mulbery, Walnut, Chullu, Kathal, Aonla, Carissa etc. were planted as cash generating species. In future, villagers will get fuel, fruits and fodder from this plantations and these sites will promote income generation in the villages. The plantations are now being maintained by the villagers.

AFRI

Project 1: Productive propagation of remunerative medicinal plants for establishment of silva-ayurveda demonstrative models in the arid and semi arid areas, their preservation for further improvement, research, extension, development and diversification. (AFRI-70/AFE/NMPB/2006-2009)

Findings: Plants of some species like *A. indica* (neem) *Cordia myxa* (gunda), *Ziziphus jujuba* (ber), *P. cineraria* (khejeri), *T. undulata* (rohida) *Moringa oleifera* (sahjan), *Caraissa carandas* (karoda), *Commiphora wightii* (guggal) were raised at AFRI nursery.Plants of some medicinal plant species like Aloe vera, Brahmi, Ashwagandha etc were procured from outside sources.

Two sites at Tibna and Jadan of Jodhpur and Pali districts respectively were planted & maintained. Fifteen field beneficiaries were selected at Tibna village, two of one hectare and thirteen of one bigha area. Total area planted is 5.75 ha. at village Tibna. The species of *A. indica* (neem) *Cordia myxa* (gunda), *Ziziphus jujuba* (ber), *P. cineraria* (khejeri), *T. undulata* (rohida) *Moringa oleifera* (sahjan), *Caraissa carandas* (karoda), *Commiphora wightii* (guggal) were maintained at farmers fields.

Some of the farmers have shown their interest to plant Aloe *vera* (guwarpatha), and *Withania somnifera* (ashwagantha). Total area planted is 5.75 ha. at village Tibna. At Jadan, species *T. undulata* (rohida),*P.cineraria* (khejeri), *Cordia myxa* (gunda), *Ziziphus jujuba* (ber), *Emblica officinalis* (aonla) *Commiphora wightii* (guggal) and Citrus (nimbu) were maintained over 1.25 ha. The survival percentage in the field ranged 70 % to 90 %.

At AFRI, Jodhpur nursery 4,20,000 nos. of *Aloe vera* plants were transplanted in thirty five nursery beds, which were procured from SKN College, Rajasthan Agriculture University, Jobner. These are being maintained by providing proper shelter and irrigation. Field nursery at Tibna was maintained by providing watch and ward. It contains about 45,000 seedlings.

An experiment on "Production Study of Medicinal Plants Integrated with tree and shrubs in the Indian Desert" was established at experimental fields of AFRI, Jodhpur with two shrub species i.e. Nimbu and Guggal and tree species Gunda and Khejri in Randomized Block Design.

Project 2: Establishment of a network to facilitate collection, processing and dissemination of statistics pertaining to tropical timber and other forestry parameters in India.(AFRI-86/Silvi/ITTO/2007-2009)

Findings: Data regarding forestry statistics collected from Rajasthan, Gujarat and Dadra & Nagar Haveli were compiled in various formats and sent to the ADG (Stat.), ICFRE. The revised formats developed in consultation with the ITTO consultant were field tested and comments given by the Forests Departments were forwarded to the ADG (Stat.), ICFRE. Draft manual was finalized and report prepared.

Project 3: Assessment of soil carbon stock and dynamics in forest soils of India. (All India coordinated project, funded by MoEF, GoI). (AFRI- 91 /FED/NATCOM-II,MoEF /2009)

Findings: From July 2008 to January 2009, a total of 111 soil samples (98 from forest areas and 13 from agriculture land) in 0-30 cm soil layer were collected from 26 forest sub group types identified covering 6 districts of Gujarat and 16 districts of Rajasthan.

Soil organic carbon (SOC) was lowest ($P<0.05$) in Desert dune forests (0.04%) and highest in Northern dry mixed deciduous forest (1.16%). But soil carbon density was highest ($P<0.05$) in Dry tropical riverain forest (38.92Mg ha^{-1}) and lowest in Tropical Euphorbia scrub (1.46 Mg ha^{-1}). Thus, carbon density depended upon soil conditions as well as gravel content and rock outcrop in particular type of forests. SOC and carbon density were in reverse order in *A. leucoploea* based and Salvadora *oleoides* based *Cassia auriculata* scrub. Boswellia forests (5/E2) occupied highest altitude, whereas Rann Saline thorn scrub (6/E3) occupied lowest altitude. Carbon density was relatively greater in Rajasthan than in Gujarat forests. Lesser carbon density in most of the forest types than in the agriculture land indicates varying degree of degradation resulting in less carbon storage. However, Dry tropical riverain forest, Dry Teak Forest, Northern dry mixed deciduous forest and Desert Thorn forests showed highest carbon density than in agriculture land reflecting better soil health in these forest types by maintaining greater soil carbon stock. Wide variability in carbon density between forests and agriculture land indicated scope of carbon stock improvement in forests.

TFRI

Project 1: Identification of species and ethno-botanical survey. [ID no. 088/ TFRI/2005/Bio-3(CGMFD) (6)]

Findings: Nine PPAs of 5 divisions were quantitatively and qualitatively analyzed as per resource survey methodology. About 50 sample plots of 0.1 ha with stratified systematic sampling design were

laid out in 1000 ha area of each PPA. Four subplots of 5 x 5 m size were laid out inside the main plot. Each one of them was marked at a distance of 11.2 m from the centre of the plot on all four sides. Study of important medicinal plants and MFP species on each plot was done. Five subplots of 2 x 2m were laid out inside the main sample plot for the study of regeneration.

Phytosociological (qualitative and quantitative values for structure and composition) studies were undertaken in all the nine people protected area of 0.1 ha each site. All individuals of > 10 cm CBH (Circumference at breast height at 1.37 m) were enumerated. Data were recorded in all fifty sample plots of each 9 PPA.

The vegetation data were quantitatively analysed for density, frequency and basal area. The relative values of frequency, density and dominance were also determined. These quantities were summed up for getting Importance Value Index (IVI) of individual species. On the basis of IVI, dominant, co-dominant and main associated species are recognized in different sites. The composition of forest and regeneration status along with other growth parameters such as girth was also enumerated.

Enumeration of vegetation in the Makadi range indicated the presence of 2347 trees of over 10 cm cbh/gbh in 0.1 ha sample plot. It is represented by 29 families, 49 genera and 62 species. Plant community was recognized accordingly as *Shorea* - *Terminalia* community. A density of 469.4 trees /ha was found. *Shorea robusta* was found dominant with 110.6 trees/ ha followed by *Terminalia tomentosa, Buchanania lanzan* and other species. Basal area of trees ranges from 7.769 m^2/ha to 0.02m^2/ha. Total 62 tree species were enumerated. Forty one species of medicinal plants were recorded in Makadi PPA.

Antagarh PPA indicated the presence of 3671 trees of over 10 cm cbh/gbh in 0.1 ha sample plot. It is represented by 24 families, 37 genera and 62 species. On the basis of density the species *Cleistenthus collinus* secured the highest value (146.4 trees/ha) followed by *Shorea robusta.* Plant community was recognized accordingly as *Cleistenthus* - *Shorea* community. Total basal area 11.44 m^2/ha was observed. Total 43 tree species were enumerated. 37 species of important medicinal plants were inventorized.

In Dugli PPA of Dhamtari area 41 tree, 10 shrub, 26 herb, 14 climber and 2 grass species have been observed. 41 tree species belongs to 19 families and 37 genera. Plant community was recognized as *Shorea – Terminalia* community. Total 41 tree species were enumerated. Density under Dugli PPA was 501.8 trees/ha and basal area 7.01 m^2/ha was observed. Total 39 species of important medicinal plants were listed out.

Enumeration of vegetation in the PPA Sankra range indicated the presence of 3142 trees. It is represented by 25 families, 47 genera and 53 species. Plant community was recognized as *Shorea-Cleistenthus* community. A density of 628.4 trees /ha was found *Cleistenthus collinus* was found as dominant species with 115.4 trees/ ha. Basal area of trees ranged from 3.75 to 0.002m^2/ha. The highest basal area was shown by *Shorea robusta*. Total 53 tree species and 26 important medicinal plants were recorded.

The vegetation in the Karpawan PPA indicated the presence of 2445 trees. It was represented by 27 families 51 genera and 60 species. Plant community was recognized as *Shorea- Terminalia* community. The total density was 489 trees /ha. *Shorea robusta* was found as dominant with 110 trees/ ha. The highest basal area was shown by *Shorea robusta*. Total 60 tree species were quantitatively enumerated and 77 species listed as important medicinal plants.

Enumeration of vegetation in the Machkot PPA indicated the presence of 2232 trees. It is represented by 27, families 46 genera and 56 species. Plant community was recognized as *Shorea-Pterocarpus* community. Total density was 469.4 trees /ha. *Shorea robusta* was found dominant with 99.2 trees/ ha. Overall total basal area covered by the trees was 13.42 m^2/ha. 54 tree and 77 medicinal plants species were recorded.

The vegetation in the Guriya PPA indicated the presence of 2181 trees. It is represented by 28 families, 50 genera and 55 species. Plant community was recognized as *Shorea- Pterocarpus* community. Total density was 436.2 trees /ha and *Shorea robusta* was found dominant with 131 trees/ ha. The total basal area of trees in the area was 25.1 m^2/ha. Total 55 tree and 59 medicinal plant species recorded.

Vegetation in the Ataria PPA of Lamni range indicated the presence of 3236 trees. It is represented by 21 families, 38 genera and 42 species. Plant community was recognized as *Shorea-Terminalia* community. Total density was 647 trees /ha. It indicated high density and highly protected area. *Shorea robusta* was found as dominant with 181.6 trees/ ha. The total basal area of trees in the area was 11.87 m^2/ha. *Shorea robusta* showed the highest basal area. 42 tree species were enumerated and 41species of medicinal plants recorded.

The vegetation in the Keonchi PPA, indicated the presence of 1172 trees. It is represented by 20 families, 33 genera and 37 species. Plant community was recognized accordingly as *Shorea- Terminalia* community. Total density was 468.4 trees /ha and *Shorea robusta* was found as dominant species. The total basal area of trees in the area was 34.23 m^2/ha. Total 37 tree species were enumerated and 72 species of medicinal plants were recorded.

In all, 1114 species of flora (tree, shrub, herbs, grasses and climbers) in all PPAs including species observed in low intensity and under threat were also listed.

Project 2: Screening of indigenous species of *Trichogramma* Westwood and *Trichogrammatoidea* Girault (Hymenoptera: Trichogrammatidae) from central India and their utilization against important forest insect pests. [077/TFRI/2005 / Ento-(1) 9].

Findings: Of the 2590 specimens collected from Madhya Pradesh,Chhatisgarh, Maharastra and Orissa, 37 species of *Trichogramma viz. T. achaeae*, *T. agriae, T. breviciliata, T. latipennis, T. kankerensis*, *T. chilotraeae, T. flandersi, T. fasciatum, T. hesperidis, T. higai, T. plasseyensis, T. raoi, T. sembeli, T. semblidis, T. pallidiventris, T. vargasi, T. thalense, T. sericini, T. julianoi, T. bezdenkovii, T. parkeri, T. brevicapillum, T. nomlaki, T. tshumakovae, T. fuentesi, T. ingricum, T. savalense, T. margianum, T. rossicum, T. ostriniae, T. artonae, T. clotho, T. lachesis, T. lenae, T. pretiosum, T. poliae, T. stampai* ,and

04 species of *Trichogrammatoidea* viz. *Trichogrammatoidea bactrae, T. fumata, T. armigera & T. ruficorpa* were recoded for the first time from central India.

Ten species of genus *Trichogramma* and two species of Trichogrammatoidea are proposed as the species new to science. Complete host-range has been prepared, after consulting the world literature for all available species of *Trichogramma* & *Trichogrammatoidea*. Live culture of 4 indigenous species viz., *Trichogramma raoi, T. plasseyensis, T. latipennis & T. breviciliata* are being maintained.

Project 3: Standardization of sustainable harvesting practices of Arjuna (*Terminalia arjuna)* Bark. [ID.No. 078/TFRI/2005/NWFP-1(MPFED) (12)]

Findings: Presently the bark of Arjuna is being extracted through unscientific and destructive harvesting practices. This is the first study on development of sustainable harvesting practices of Arjun bark. *T. arjuna* has the ability to withstand bark removal as long as the vascular cambium is not destroyed.

The study revealed that the regeneration of bark in young trees was faster in comparison to old trees. The bark was regenerated in two years. The medium aged trees gave better quality of bark in terms of their major active ingredients. The best time to harvest bark was found between March and April. The study recommends that for sustainable harvest, only ¼ or $1/3$ of the mature bark of total girth of the tree should be stripped by removing only outer and middle bark leaving the inner bark for regeneration from opposite quarters of the trunk. Thus sustainable bark harvesting can be done after every two years by removing opposing quarters of trunk bark rather than girdling the trees.

Project 4: Standardization of non-destructive harvesting practices of Aonla (*Phyllanthus emblica*), *Baheda* (*Terminalia bellerica*) and *Baividang* (*Embelia ribes*) fruits. [097/TFRI/2005/NWFP-8 (CGMFD) (20)]

Findings: The study revealed that harvesting time plays very important role in maintaining the sustainability because only mature fruits produce viable seeds. The fruits if harvested at right maturity in Aonla (December-January), Baheda (January-February) and Baividang (November-December), they produce viable seeds. Even small quantities of fruits (5-10%) were found sufficient for regeneration. The study also suggests that anthropogenic pressures other than harvest could be responsible for difference in regeneration between protected and unprotected areas, which are managed under similar harvest intensities. Grazing and fire is the major causes for poor regeneration. In protected areas, 10-20 % Aonla fruits were found sufficient for regeneration. However, in unprotected areas less regeneration was observed even if 20% fruits were left for regeneration. In Baividang, 5-10 % fruits were found enough for proper regeneration in protected areas of Dhamtari district in good fruiting year if harvested in December. In Baheda, even 5-10 % fruits were found suitable for its regeneration in protected areas if harvested in the month of January. In Baheda, the seed dispersal is very poor. For proper dispersal and to maintain sustainability, mature seeds should be dispersed in the forest area. These practices may be helpful for the sustainable management of these important medicinal plants.

Project 5: Standardization of non-destructive harvesting practices of Arjun (*Terminalia arjuna)* and Maida (*Litsea glutinosa*) bark. [096/ TFRI/ 2005/ NWFP-8 (CGMFD) (19)

Findings: The study revealed that the regeneration of bark in young trees was faster in comparison to older trees. In Arjuna, the bark was regenerated in two years whereas in Maida it took only one year. In Arjuna, the quality of trunk bark was superior in comparison to the bark of other plant parts, whereas no significant difference was found in Maida. In Arjuna, the bark thickness at breast height varied from 8.12 to 20.96 mm and was found to be irrespective of the age/girth of tree. The tannin content in Arjuna bark ranged from 6.89 to 11.83 gm per 100 gm. Mature Maida trees had thick bark with less mucilage content in comparison to younger trees. The study also showed that the stage of bark recovery (regrowth) varied from tree to tree. Arjun showed remarkable bark regrowth in moist sites. The medium aged trees gave better quality of bark. The best time to harvest bark was found between December and March. The study recommends that for sustainable harvest, only ¼ or $1_{/3}$ of the mature bark of total girth of the tree should be stripped by removing only outer and middle bark leaving the inner bark for regeneration from opposite quarters of the trunk. The length of blaze/strip can be upto 1.20 meter depending upon girth of the trees. A long strip of one quarter of the trunk may be removed with sharp thin edge tool designed for the harvest of bark.

Project-6 : Processing techniques of NWFPs of Chhattisgarh TBOs–*Madhuca latifolia, Shorea robusta,Schleichera oleosa, Pongamia pinnata* and *Buchanania lanzan*. [ID No. : 091/TFRI/2005/NWFP-3(CGMFD)(14)

Findings: Study conducted on processing of Tree Borne Oil seeds (TBOs) *i.e.*. Sal (*Shorea robusta*), Chironjee (*Buchanania lanzan),* Karanj (*Pongamia pinnata)*, Mahua *(Madhuca latifolia)* and Kusum (*Schleichera oleosa*) indicates that method of drying and storage in containers affect the quality of oil seeds severely. Different methods of drying i.e. shade, sun drying, hot air drying at 40, 60 and 80ºC were used to dry the tree borne oil seeds. Hot air drying at 60ºC proved better in comparison to sun drying /shade drying methods to maintain quality of seeds. At 80ºC, the moisture of the seeds decreases rapidly and affects the quality of seeds. Hot air drying at 60 °C for 8 hours was found to be most effective in minimizing moisture content to 7-9% without affecting oil quality and undesirable changes in lipids and its properties. The kernels obtained after processing of seeds should be dried properly before storing to avoid deterioration due to pests. This will ensure availability of good quality seed kernels for the extraction of oil with minimal deterioration.

Project 7: Quality assessment of NWFPs: *Asparagus racemosus, Buchanania lanzan, Andrographis paniculata, Phyllanthus emblica* and *Embelia ribes* from Chhattisgarh. [ID No.: 092/TFRI/2005/NWFP-4 (CGMFD) (15)

Findings: The maximum weight of fresh Aonla fruits was recorded as 6.89 gm, pulp weight 6.44gm and ascorbic acid was recorded as 197.2mg/100 gm fresh aonla in samples collected from Ambikapur. In Jabbara Nagan, the maximum fresh weight of Aonla was recorded 6.447 gm and the pulp weight was

6.53 gm and ascorbic acid 143.5 mg /100 gm of fresh weight. Ascorbic acid contents was found to be significantly higher in aonla samples collected from Kanker. Maximum weight of fresh fruit was recorded 5.77 gm, pulp weight 4.99 gm and ascorbic acid 326.3 mg/100gm of fresh fruit.

The fruit weight of Chironjee ranged from 0.552 to 0.802 gm with maximum fruit weight in Kapu, Dharumjaigarh samples. Samples collected from Kudur, Kawardha showed maximum kernel weight (1.20 gm) and oil (62.57%).

Out of 20 localities surveyed for the quality of Chironjee, the maximum fruit weight of 0.802 gm was recorded from Kapu and Dharmngaigarh samples. The maximum oil percentgage 62.57% was observed from the samples collected from Kudur and Kawardha.

Roots of Satawer (*A.racemosus)* were collected from 22 localities of Chhattisgarh during the month of April-May. Maximum average root length of 25.35cm and dia 1.02 cm and saponin percentage of 2.5 % was observed in the samples of Dondi (Durg), which are significantly higher than other localities.

Kalmegh samples were collected from 19 localities. Andrographolide contents were observed to vary from 0.27 to 0.49%. Maximum andrographolide content was found in the samples collected from Jagdalpur (0.49%).

Physical and chemical parameters of fruits of *Emblia ribes* were studied in samples collected from 5 localities of Chhattisgarh. The moisture % and embelin contents were estimated. Embelin concentration was ranged from 1.98-2.94%. Maximum concentration of 2.94% was estimated in the sample collected from Jabbara, Dhamtari.

Project 8: Non destructive harvesting practices for selective MFPs species–*Buchanania lanzan* (Chironjee). [ID No.: 093/TFRI/2005/NWFP-5 (CGMFD) (16)

Findings: Surveyed and selected nine different Chironjee growing areas of Chhattisgarh state.The fruits were harvested on the basis of occular/ visual observations and number of branches per tree. Fruits were collected non destructively either by hand or with the help of long bamboo sticks. Sometimes beaten slowly to help fallen the fruits

Annual recruitment of young seedlings varied from site to site. Harvesting 90% fruits at Kota, Bilaspur resulted 7.90, 9.04 and 8.20% seedling recruitment in Ist, IInd and IIIrd years, respectively. In non-harvested control sites, it was 5.80, 9.69 and 9.69% respectively. It indicates that the population is increasing both in controlled as well as in different levels of harvesting.

Project 9 : Sustainable yield assessment/harvesting of Non Wood Forest Produce (NWFP) in People's Protected Areas (PPAs) of Chhattisgarh. [098/TFRI/2005/Silvi-3 (CGMFD -10)]

Findings: Sample plots of *Andrographic paniculata* (Kalmegh), *Aspargus racemosus* (Satawar) *Celastrus paniculata* (Malkangani) and Ae*agle mrmelos* (Bel) were laid out in three agro-climatic zones (Bastar, Raipur and Bilaspur) of Chhattisgarh.

Sustainability for *Andrographic paniculata* with maximum productivity was found to be at 80% harvesting level. As such 80% of entire plants of *Andrographic paniculata* may be harvested. Sustainability for *Aspargus racemosus* with maximum productivity was found to be at 60% harvesting level. Eight month old plants of *Aspargus racemosus* should only be harvested.

Sustainability for *Celastrus paniculata* with maximum productivity was found to be at 80% harvesting level. Similarly, sustainability for *Aeagle mrmelos* (Bel) with maximum productivity was found to be at 80% harvesting level. Regeneration through root suckers was found better than through seeds. Regeneration through root suckers by hoeing 10-15 cm. deep is advisable around the trees.

Socio-economic status and living standard of people in JFM areas have been found to be better due to implementation of the scheme by way of employment and enhancement of production of medicinal plants.

Project 10: Nursery technologies for mass multiplication of superior seedlings of Vaividang, Sarpgandha, Chironjee, Arjun, Aonla, Bel in Chhattisgarh. [099/TFRI/2005/Silvi-4 (CGMFD -11)]

Findings: Nursery technologies for mass multiplication of superior seedlings of *Embelia ribes* (Vaividang), *Rauvolfia serpentina* (Sarpgandha), *Buchanania lanzan* (Chironjee), *Terminalia arjuna* (Arjun), *Emblica officinalis* (Aonla), Ae*agle marmelos* (Bel) in Chhattisgarh were standardized.

IFGTB

Project 1: Germplasm collection and production of improved planting stocks of *Terminalia chebula* Retz and *Terminalia bellirica* (IFGTB/EF-RP-25/ 2005-2008)

Findings: Selection criteria for identifying superior trees in terms of fruit yield and quality have been standardized for *T. chebula* and *T. bellirica*. Superior trees of *T. chebula* (85) and *T. bellirica* (19) were selected based on fruit yield, fruit size and fruit color in various places viz., Talawadi, Kallar, Bargur, Kalrayan hills, Courtallum, Chitteri hills, Javadhu hills and Nagarcoil in Tamil Nadu. Nursery techniques including seed processing, seed treatment, biofertilizer dosage etc., have been standardized for both the species. Vegetative propagation in *T. chebula* and *T. bellerica* have been standardized. Among the rooting of branch cuttings, airlayering, budding and grafting the wedge grafting method found to be relatively successful. Grafting of selected trees was attempted and wide variation was observed for response to cleft grafting. A germplasm bank of 9 *T. chebula* and 3 *T. bellirica* clones has been

established at Panampally. Methods for estimation of medicinally active major biochemical compounds have been standardized. Four distinct populations of *T. chebula* and five populations of *T. bellirica* were screened for medicinally important biochemical compounds like total phenols, tannins, gallotannin, free gallic acid and ellagitannins to investigate the relationship between geographic location and the biochemical content. Though different populations showed variation for all these compounds, the tree to tree variation was also high within a population. Significant levels of variation for various active compounds content in fruits of selected superior trees were also observed.

Project 2: Germplasm conservation and establishment of seed stands for production of quality seeds and seedlings (IFGTB/EF-RP-09/2003-2006; Extended up to 2008)

Findings: Tree selection strategies were developed for *Aegle marmelos, Saraca asoca, Asparagus racemosus, Gymnema xylvestre, Tinospora cordifolia, Emblica officinalis* and *Oroxylum indicum* based on their distribution patterns, medicinal importance and threatened status. Appropriate seed handlings methods were also worked out. Vegetation propagation techniques and seed germination methods were standardized. Population survey was conducted in the States of Tamil Nadu and Kerala to identify and select trees/plants ased on the selection strategies. *Aegle marmelos* from 14 locations, *Asparagus racemosus* from 9 locations, *Gymnema sylvestre* from 9 locations and *Tinospora cardifolia* from 8 locations were collected, vegetatively propagated and assembled in the Medicinal Plants Seed Production System established in an area of about 1 Ha at Anaikatti, Tamil Nadu. Accessions of the above medicinal species from different locations in the states of Tamil Nadu and Kerala were assembled in the Institute. These accessions have been utilized to establish a germplasm bank cum seed production system for medicinal plants at Anaikatti in Tamil Nadu. The system has been established in an area of 1 ha including wild accessions of *Tinaspora cordifolia* (33), *Gymnema sylvestre* (15), *Saraca asoca* (6), *Asparagus racemosus*(20), *Aegle marmelos*(24), *Emblica officinalis* (6), *Strychnos potatorum* (1), *Oraxylum indicum* (2) and *Rauvolfia serpentine*(3).

Project 3: Field Performance of Micro and Macro-Propagated planting stock of selected five commercially important Bamboo Species [IFGTB EF-RP 17]

Findings: Twenty five hectares field plantations were established to study the performance of micropropagated plants of three species of bamboos, *B.bambos*, *D.strictus* and *P.stocksii* at four locations in Coimbatore and Salem districts. Among the three species tested, *B.bambos* showed better growth than *P.stocksii* and *D.strictus*, however the utility value of the culms vary among the species. Micropropagated, seed raised and cuttings propagated plants show similar growth in the field conditions. Initially, cuttings raised plants showed lesser mean number of shoots, however, no significant variation was noticed after 3 years of planting. It may be due to the number of rhizomes developed during the initial phase of establishment. Bamboo propagules over 8 months old at the time of field planting were escaped from rabbit damage, hence to avoid the damage of the shoots by rabbits, it is essential to plant 8 to12 months old plants. If the newly produced culm is thick, vulnerability to rabbit damage is less. Bamboos prefer well drained loamy soil and growth and production of new culms

was highly affected in poor soils like gravel and rocky types. In irrigated conditions, the mean height of the tallest culm of micropropagated *B.bambos* at the age of 1.5 years was 4.2 m, whereas under unirrigated conditions, 4.5 year old plants showed 3.1m height. In unirrigated but good soil type micropropagated *D. strictus* was growing well than *B.bambos* and *P.stocksii*. Enough care need be taken for the plants during the initial years of establishment especially watering and weeding. Farmer's field is preferable for bamboo cultivation than unmanaged areas (Plate). Fire hazards are not uncommon in bamboo fields and to avoid the same regular weeding is essential during the establishment stages. Watering to the bamboo plants once in 15 days is essential in low rainfall areas at least for initial three years. Number of shoots produced was similar among the propagule types and culm growth is determined by the water availability. Supply NPK along with farmyard manure promoted the growth of bamboo plants than providing farmyard manure alone. A bamboo germplasm garden with 37 genotypes belonging to 19 species was established under this project.

Project 4: Population Structure and Reproduction in Bruguiera and Ceriops: Implication on Conservation [IFGTB EF-RP 26/2005 - 2008]

Findings: Studies were concluded on the pollination, floral biology and reproductive success in seven rare true mangrove species namely *Bruguiera cylindrica, B.gymnorhiza, B.sexangula, B.parviflora, Ceriops tagal and Ceriops decandra*. Detailed studies were conducted in 6 locations across the East and West Coasts. In the West Coast, Kannur and Ernakulam districts in Kerala were surveyed. The *B. cylindrica* populations in Pitchavaram, East Coast flower during April – May, whereas, in West Coast, they flower during October – November. Both sunbirds and insects pollinate *B. gymnorrhiza*. *B. cylindrica* pollinated by thrips shows the highest reproductive success. *B.sexangula* is exclusively pollinated by sunbirds exhibited the lowest reproductive success. In all the three species, the flowers produce enormous amount of pollen and show very high pollen to ovule ratio. *B. gymnorrhiza* and *B. sexangula* exhibit very high pollen fertility. Regeneration and development of families beneath mother trees was common in all the three *Brugueira* species.

Project 5: Development of post harvest techniques for seed production in *Jatropha curcas* [IFGTB EF-RP 24/2005 - 2008]

Findings: Phenology studies conducted in a plantation at Anaikatti, Tamil Nadu, over two peak flowering-fruiting seasons indicated that *Jatropha curcas* has high reproductive efficiency. The studies on maturity revealed attainment of physiological maturity when fruits turn yellow as shown by no significant variation in germination percentage among later stages of fruit ripening. With respect to harvesting maturity, though oil content among different maturity stages did not vary significantly, fruit maturity stage had considerable effect on oil physico-chemical characteristics like Acid value, Iodine No., Peroxide Value & Viscosity. The results indicate that fruits need to be harvested at late yellow stage or black pulpy stage and is safer to avoid collecting fruits at dry stage. Effect of drying method on Jatropha oil was studied in seeds extracted from fruits at black pulpy stage. Considering the oil yield, shade drying for 10 days and oven drying at 40°C for 1 day were found suitable methods. However, desirable values

for most of the oil characteristics in the oven drying treatment at 40°C for 1 day renders it superior to 10 days of shade drying treatment. Comparing the two fruiting seasons, it is found that during the second season (October-December) the oil yield and quality was more than the first (July-September). Studies on seed processing showed that it is essential to separate the shell or seed coat from seed in order to maximize oil recovery. Hence developed a prototype, 'Seed Decoater' for processing jatropha seeds which separates kernel from seed coat. The seed is broken by milling technique while the separation of seed coat from kernel is through air suction. The prototype is driven by a 1hp motor and a minimum of 10 kg seed per hour can be processed by this Seed Decoater. The separation (80% kernel and 20% seed coat) of kernel enables to check loss of oil through adsorption by seed coat and thereby maximize oil recovery. In addition, the oil from the processed seeds is found to have better physico-chemical characteristics compared to whole seed oil. Seed grading experiment revealed that soaking jatropha seeds (insect attacked seedlot) for 24 hours in water followed by 2 hours drying helps recovery of good seeds as floaters while insect attacked seeds sink. The infection in the seeds was confirmed through the X -ray images. By this grading method the germination, percentage of a poor seedlot could be substantially improved. Effect of desiccation on jatropha seeds showed that 6% moisture content is the Lowest Safe Moisture Content to which the seeds need to be dried both with regard to oil quantity and quality. Effect of storage container on seed oil parameters and viability was tested on seeds stored in different containers such as polybag, jute bag, cloth bag, paper bag and black polybag. The most apt material to store jatropha seeds was found to be cotton cloth bag or jute bag. Effect of different temperatures on storability of Jatropha suggest that seeds need be stored at 10°C (normal refrigerated conditions) for a period of one year to obtain maximum oil content with desirable characteristics. From the midstorage correction trials, it was evident that both roll towel and wet sand treatments were good midstorage correction treatments for about 12 months storage.

Project 6: Evaluation of superior planting stock of *Acacia mangium* in agroforestry systems at different eco-climatic zones of Kerala and Tamil Nadu [IFGTB/EF-RP 11/2003-2006]

Findings: Experimental plots were established with seedlings raised using the seeds collected from seed orchards of *Acacia mangium* (Mangium) in Panampalli, Kerala along with ramets of superior trees of Mangium procured from Mysore Paper Mills both in Tamil Nadu and Kerala. Intercropping was done up to third year. Biological productivity was assessed at three years - half rotation age of tree component. Observation on growth parameters at the age of three years revealed that maximum growth was recorded in southern zone of Kerala by registering girth at breast height (gbh) of 36.0 cm and total height of 15 m. The mean commercial bole height recorded was 12.7m in this zone. Minimum growth recorded was in central zone of Kerala with gbh of 24.5 cm and total height of 6.6 m. The gbh and total height recorded in southern zone of Tamil Nadu was 30 cm and 6.1 m respectively. In turn, volume production was highest at southern region of Kerala registering 79.12 m^3 ha^{-1} compared to central zone of Kerala (13.56 m^3 ha^{-1}) and southern zone (10.64 m^3 ha^{-1}) of Tamil Nadu. Results on biomass studies revealed that estimated wood yield (on fresh weight basis) at 3 years was 54.0 MT ha^{-1} in southern zone of Kerala which was 4-6 times greater than that registered in central zone of Kerala (12.0 MT ha^{-1}) and in southern zone of Tamil Nadu (9.0 MT ha^{-1}). While comparing the performance of

seedlings of Mangium with that of hybrids of Mangium, more dry matter allocation in branch biomass was observed (17 to 28%) in hybrids of Mangium than in seedling raised plantations (5 to 16%). With heavy branching habit, the hybrids of Mangium are not suitable for agroforestry system.

Among different agricultural crops intercropped with *A. mangium*, blackgram, horsegram, fodder sorghum and beans were found to be compatible and onion was observed to be less compatible. The recommended agroforestry systems are i) *Acacia mangium* + Green Beans based system for Tamil Nadu and ii) *Acacia mangium* + Pepper based system for Kerala.

Project 7: Infrastructure development of the Botanical Garden of the Institute of Forest Genetics and Tree Breeding and *ex*-situ conservation of selected Rare and Threatened species (Funding Agency: MoEF)

Achievements: Infrastructure development work like repair of green house, laying out path and irrigation pipeline and labelling of plants in the garden has been completed. 140 plant species have been introduced and maintained in the Botanical Garden.

Project 8: Establishment of seed production systems for NTFPs of Attapady Hills [IFGTB/EF RP /2006 -2008]

Findings: Agriculture and sale of minor forest products are the two traditional income sources to the Attapady tribals. The species selected for the study are the major NTFP yielding species for the tribal communities which face destruction due to their destructible harvest. Population status of the NTFPs was studied. Seed handling procedures were developed in *Acacia concina, Caesalpinia sappan, Terminalia chebula.* Different NTFP species harvested were collected from Attapady Reserve Forest; studies conducted and produced seedlings for the establishment of Seed Production System (SPS). A seed production system has been established in an area of 1.615 ha. The species *Aegle marmelos, Saraca asoca, Oroxylum indicum, Acacia concina, Terminalia chebula, Asparagus racemosus* and *Caesalpinia sappan* have been planted. The espacement followed is 5 x 5 m with pits of size 50 x 50 x 50 cm. The tribal farming society was involved in the establishment of the SPS right from the time of site preparation and has been giving protective watering and maintenance till date. The survival of the plants at the end of 3 months was 84 % on an average (ranging from 78-91 depending on the species) and at the end of 6 months it is 70 % on an average (ranging from 70-90 depending on the species). The Vattaluki Tribal Farming Society (VTFS) is the beneficiary of the project output.

IFP

Project 1. Documentation and inventorization of indigenous traditional medicinal knowledge in selected districts of Jharkhand (Funded by NMPB) [IFP-033/EBC–4/ NMPB /2005 – 08]

Findings: Traditional medicinal practices commonly used by 22 tribes of Jharkhand were documented. Herbal remedies for common ailments among ethnic communities *viz.* Arthritis, Diarrhoea, Dysentery, Spermatorrhoea, Bone facture, Epilepsy, Piles, asthma, hyperacidity, Paralysis, Infertility (Male & Female), Otitis, Snake bite, Dog bite, etc. were noted. Herbarium specimens were preserved for plants used by different tribes for treatment of disease symptoms. Identification of two major forests in Chhotanagpur region having rich biodiversity of flora and fauna was done.

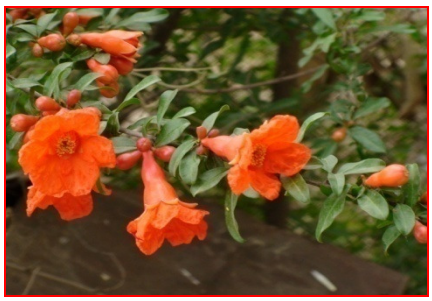
IWST

Project 1: Ecological assessment of forest areas falling under Kol Dam Hydroelectric Project in Bilaspur district of Himachal Pradesh [FT48-88/86(FCA) CATP Kol Dam–HPSFD Funded Project].

Findings: Carried out phytosociological studies in different catchment areas falling in the Forest Divisions of Bilaspur, Suket, Kunihar, Shimla, Theog and Karsog. Study in Bayali catchment of Suket forest division showed that the total number of plant species was 140 belonging to 66 families and 127 genera. In Hadaboi catchment of Suket forest division total number of plant species was 192 belonging to 72 families and 164 genera. While studying the composition of vegetation in Jattu catchment of Suket forest division, the total number of palnt species was 43 belonging to 24 families and 36 genera. In Kasol catchment of Bilaspur forest division total number of plant species was 133 belonging to 60 families and 113 genera. Kandhar catchment of Kunihar forest division revealed that the total number of plant species was 166 belonging to 56 families and 135 genera. In Tattapani catchment of Karsog forest division total number of plant species was 167 belonging to 66 families and 150 genera. Studied the composition of vegetation in Kotlu catchment of Karsog forest division and found that total number of plant species was 219 belonging to 83 families and 188 genera. In Sunni catchment of Shimla forest division total number of plant species was 227 belonging to 77 families and 194 genera. Matiana catchment of Theog forest division revealed that total number of plant species was 155 belonging to 70 families and 140 genera. The dominant families were Asteraceae, Fabaceae, Lamiaceae, Euphorbiaceae, Rubiaceae and Rosaceae. The distribution pattern of most of the plant species was contiguous in all the catchments. Out of 128 medicinal plant species recorded from the various catchments, 6 species i.e. *Dioscorea deltoidea, Taxus wallichiana, Zanthoxylum armatum, Gloriosa superba, Roylea cinearea, Valeriana jatamansi* fall in the category of threatened plants.

Gloriosa superba

Cassia fistula



Punica granatum

Adhatoda zeylanica

Project 2: Study on plant diversity in Rakchham, Chitkul Wildlife Sanctuary of district Kinnaur Himachal Pradesh [GBPI/IERP/04-05/15/862-GBPI Funded Project]

Findings: Phyto-sociological studies were carried out at various altitudes in Doje forest, Kanasa area and Shone Khad area of Rakchham beat; Hitch Pawang, Murti Panag, Rani kanda to Jarra and Tumer area of Chitkul beat; Rasrang, Hurba and Shingan area of Batseri beat of the sanctuary. In Doje Forest, number of trees, shrubs and herb species were 15, 31 & 117 with dominance of *Betula utilis, Hippophae salicifolia and Polygonatum verticillatum* respectively. In Kanasa Nala, number of trees, shrubs and herbs species were 9, 23 & 122 with dominance of *Acer acuminatum, Rhododendron campanulatum* and *Polygonum polystachya* respectively. In Shone Khad, number of trees, shrubs and herbs species were 11, 23 & 115 with dominance of *Hippophae salicifolia, Juniperus indica* and *Rumex nepalensis* respectively. In Hitch Pawang, number of trees, shrubs and herbs species were 3, 29 & 103 with dominance of *Pinus*

Betula utilis Forest

wallichiana, Lonicera parvifolia and *Polygonum polystachya* respectively. In Murti Panag, total number of tree, shrub and herb species were 7, 18 & 97 with the dominance of *Betula utilis, Berberis jaeschkeana* and *Potentilla atrosanguinea* respectively.

Hippophae Rhododendronlepidotum tibetana

In Rani Kanda to Tumer Nala, the number of trees, shrubs and herbs species were 1, 11 & 74 with dominance of *Betula utilis, Rhododendron anthopogon* and *Polygonum polyatachya* respectively. In Rani Kanda to Jarrya top**,** the number of trees, shrubs and herbs species were 1, 8 & 98 with dominance of *Betula utilis, Juniperus indica* and *Thymus linearis* respectively. In Rasrang area, the number of trees, shrubs and herbs species were 13, 25 & 70 with dominance of *Cedrus deodara, Abelia triflora* and *Rumex nepalensis* respectively. Whereas, in Hurba area**,** the number of trees, shrubs and herbs species were 9, 25 & 73 with dominance of *Betula utilis, Juniperus communis* and *Caltha palustris* respectively. In Shingan area**,** the number of trees, shrubs and herbs species were 13, 26 & 95 with the dominance of *Betula utilis, Rhododendron anthopogon* and *Thymus linearis* respectively. Three species of Rhododendron viz., *Rhododendron companulatum, R. anthopogon*, and *R. lepidotum* were also recorded from the sanctuary. The distribution pattern of plant species was mostly contiguous in all the studied areas. The population structure of various tree species occurring in different areas of the sanctuary was estimated and recognized three patterns of population structure. Out of 105 medicinal plant species recorded from the various areas, 27 plant species fall in the category of threatened plants. Conducted ethno-botanical studies in Rakchham, Chitkul, Batseri, Themgarang, Boningsaring villages and documented 50 plant species used for various purposes.

Project 3: Inventorization, documentation and to evolve site specific management strategies for the conservation of sacred groves of Kullu Valley in Himachal Pradesh. (GBPI/IERP/04-05/18/865).

Findings: A total of 33 sacred groves were inventorized in the Kullu valley and these sacred groves were found rich in plant biodiversity. A total of 224 plant species were recorded. The sacred groves serve as storehouse of medicinal plants. During the study, ethnobotanical information on 69 plant species were

also documented. Deodar (*Cedrus deodara*) was recorded as the dominant tree species in most of the sacred groves. However, the number of deodar trees varied among the sacred groves. A pamphlet on "*Dev van Ek Prachin Dhrohar*" was prepared for creating awareness among the local community for conservation and rejuvenation of sacred groves. Reasons for degradation of individual sacred groves were identified and site-specific management strategies for rejuvenation and conservation of the sacred groves were evolved with the participation of people.

Project 4: Studies on population status and berberine content in different provenances of *Berberis aristata* DC. in Himachal Pradesh and standardization of its propagation techniques (BT/PR4695/PBD/17/300/2004 dated 13th May 2005).

Findings: Seven provenances of *Berberis aristata* were identified in Himachal Pradesh. After identification of different *Berberis aristata* provenance/populations, root samples were collected, cut into small pieces, dried in shade and sent to the Forest Research Institute, Dehradun for estimation of berberine content. The chemical analysis showed maximum berberine content of 2.81 % in sample no.30 followed by 2.70% in sample no. 5. The high berberine yielding plants identified in this study were mass propagated through stem cuttings, but the rooting percentage and survival of the rooted cuttings were very less. Although, the vegetative propagation of the species is very difficult, the species can be easily propagated through seeds.

RFRI

Project 1: Establishment of a network to facilitate collection, processing and dissemination of statistics pertaining to tropical timber and other forestry parameters in India. [RFRI/EP/16/2006-2008]

Findings: Project concluded on 31st December 2008. Required information was submitted to the Directorate of Extension, Division of Statistics, ICFRE Dehradun. The revised format received from ICFRE was communicated to all State Forest Departments of NE states for submission of forestry statistics information.